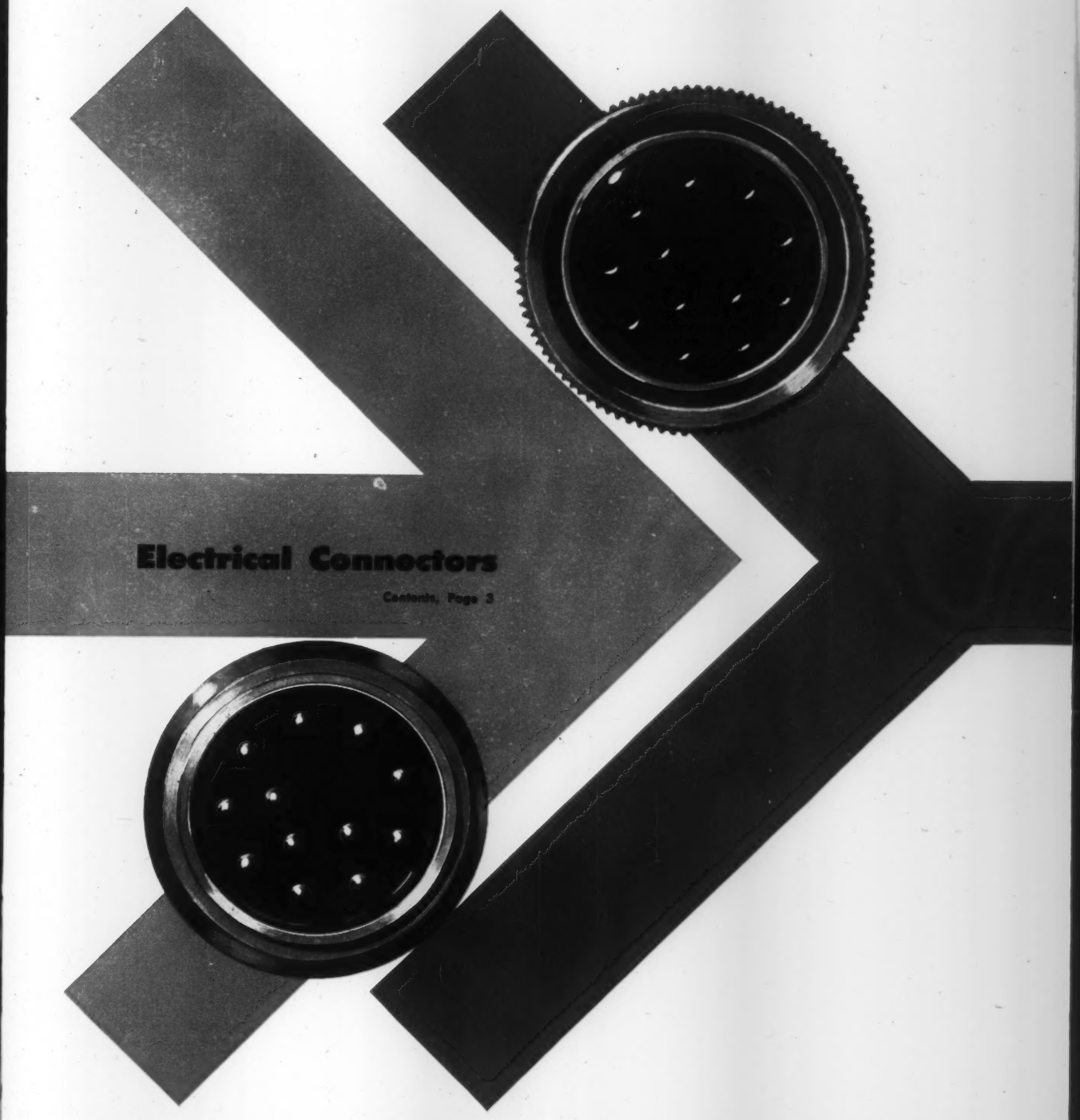
NOVEMBER 26, 1959

MACHINE DESIGN

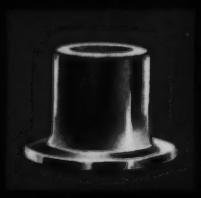
A PENTON PUBLICATION — BIWEEKLY



Electrical Connectors

Contents, Page 3

FARNSWORTH



Your order can be this small. One self-lubricating bearing, custom made. You'll get the same prompt, interested service as you would if you ordered Bound Brook bearings by the ton.

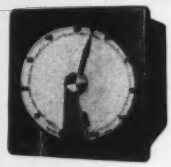
Circle 401 on Page 19

BOUND BROOK

Bound Brook Oil-less Bearing Co., Bound Brook, N. J.
Pioneer in Powder Metallurgy Bearings and Parts.
Plants at Bound Brook, N.J. and Sturgis, Mich.

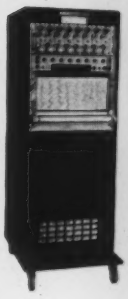
HERE'S WHY..

Leading instrument manufacturers power their products with Bodine Motors



LEEDS & NORTHRUP SPEEDOMAX® H INSTRUMENTS

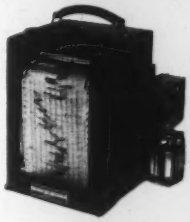
"Our Speedomax H line includes indicators, recorders, and controllers, which measure or control temperature, pH, gas concentration, power and load, and neutron density in many industrial, power plant, and research applications. These instruments are designed for 24-hour operation, seven days a week. All components must be rugged, dependable. Many of the instruments in the Speedomax H line are powered with Bodine Motors."—Leeds & Northrup Company.



SANBORN OSCILLOGRAPHIC RECORDING INSTRUMENTS

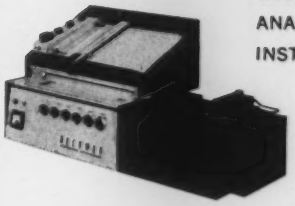
"Time is very important in recording electrical and physical properties . . . and this is one reason we use Bodine synchronous motors. These instruments can operate at nine different paper chart speeds. The motor that powers the chart moving mechanism must respond quickly . . . operate at any of the pre-determined constant speeds. Over the years Bodine Motors have met our requirements for constant speed, minimum noise, uniform performance, and long life."—Sanborn Company.

ESTERLINE-ANGUS RECORDERS



"We needed a motor that would run quietly, start fast, and accurately maintain the required speed. Also, it was necessary that both AC and DC motors have the same mounting dimensions. We wanted a source where delivery promises would be kept, and also where motor parts would be quickly available. Bodine met all these requirements, plus making our external drives less cumbersome."—The Esterline-Angus Company, Inc.

BECKMAN ANALYTICAL INSTRUMENTS



"Bodine motors are used in several of our precision instruments where critical specifications must be met and maintained. In addition, twenty-four hour operation is common place in the use of our products for important research."—Beckman Scientific and Process Instruments Division.

Free—ask for descriptive bulletins 1023B and 1024A

Bodine K-2 Motors were designed to power instruments

Many manufacturers of instruments, timing devices, control apparatus, and similar products use Bodine K-2 Motors. K-2's are small, compact motors . . . only 2⅜" high . . . perfect for those hard-to-get-at installations. Instantly reversible and totally enclosed, they're available synchronous or non-synchronous . . . with or without speed reducers. Horsepower range: 1/2000 to 1/500. Bodine Electric Co., 2508 West Bradley Place, Chicago 18.

BODINE
fractional horsepower
MOTORS

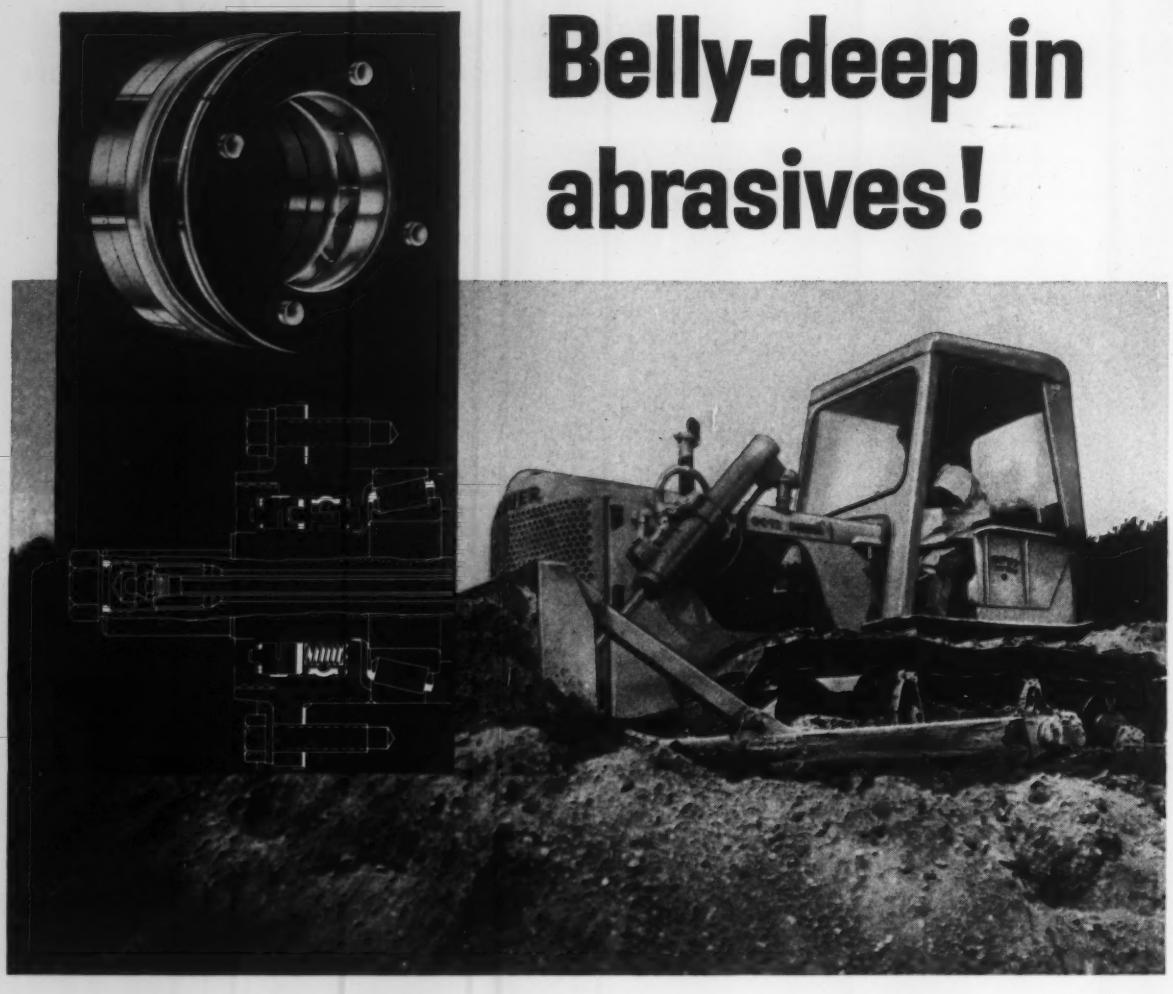
BODINE

Other applications for Bodine Motors: vending machines, communication equipment, sound recorders, automatic scales, respirators, voltage regulators, X-ray timers, traffic signal timers, stirrers, sanders, letter openers, envelope sealers . . . plus many, many other applications.

. . . the power behind the leading products

Circle 404 on Page 19

Belly-deep in abrasives!



But it can't touch her track wheel bearings

Whatever the Oliver OC-12 is bulling through . . . liquid ooze, dirt, or gale-blown desert sand . . . nothing can get into the track wheel bearings. Oliver engineers saw to that. They specified C/R Type VS End Face Seals with metal-to-metal contact to protect those bearings. The metal faces in these seals are lapped to within 3 lightbands of being optically flat. Nothing can get in . . . and the fluid lubricant inside can't get out . . . no matter how rugged the duty. Oil seal dependability like this means fewer lube checks, fewer lube changes . . . less downtime. And *that* means big savings for Oliver users.

C/R End Face Seals are performing hundreds of other critical sealing jobs . . . saving equipment, time and money. No matter what is involved . . . high speed, temperature, pressure . . . in everything from rockets and missiles to pumps, tools and washing machines . . . there's a C/R End Face Seal for the job. If it's *your* job to solve a difficult lubricant retention problem . . . share it with us. Write for detailed information on C/R End Face Seals.

More automobiles, farm and industrial machines rely on C/R Oil Seals than on any similar sealing device.

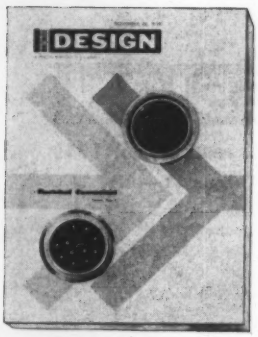
CHICAGO RAWHIDE MANUFACTURING COMPANY

OIL SEAL DIVISION: 1221 ELSTON AVENUE • CHICAGO 22, ILLINOIS
Offices in 55 principal cities. See your telephone book.
In Canada: Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario
Export Sales: Geon International Corp., Great Neck, New York

C/R Products: C/R Shaft and End Face Seals • Sirvene (synthetic rubber) molded pliable parts • Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-metallic Gears

C/R

Circle 405 on Page 19



Front Cover: The two halves of an electrical connector—male and female—are shown both literally and symbolically on George Farnsworth's cover design. Article on Page 120 by Robert Eklund tells how connectors can be applied in signal and power circuits.

November 26, 1959

Seam-Stitched Pneumatics 24

News Report—How the new Navy blimps keep large volumes of low-pressure helium under control with giant fabric lungs that "breathe" air.

Reliability or Liability? 112

ALBERT WOODRUFF GRAY—Standards established by the courts for measuring a manufacturer's legal responsibility for the safe operation of his product.

Electrical Connectors 120

ROBERT L. EKLUND—A designer's guide to selection of connectors for signal and power circuits: Connector types, electromechanical factors, environmental factors.

Supplying Lubricant to Sleeve Bearings 132

HARRY C. RIPPEL—Methods for calculating flow rate of pressurized lubricant in typical groove configurations and for applying lubricant in nonpressure systems.

Thermal Stresses in Design 143

S. S. MANSON—*Part 16: Measurements by Photoelasticity*—Basic concepts and techniques in the use of photoelastic models for thermal-stress determinations.

Polycarbonate Plastics 152

RICHARD J. THOMPSON—Characteristics of a completely new family of tough, heat-resistant thermoplastic molding compounds with good electrical insulating properties.

Solving Equations 155

JOHN P. HATCH—*Data Sheet*—How to find the roots of cubic or higher-degree equations with a simple procedure that combines interpolation and Newton's method.

Flexible Hose for Hydraulic Systems 159

D. WENDELL FENTRESS—*Design Abstract*—Selection factors for current hose types.

CONTINUED NEXT PAGE

THE PROFESSIONAL JOURNAL FOR ENGINEERS & DESIGNERS

MACHINE DESIGN

November 26, 1959
Volume 31 — No. 24

Tolerance or Indignation? 111
COLIN CARMICHAEL—*Editorial*

Engineering News 6

Lithium-aluminum alloy 6
Engineer-school problems ... 6
Astronaut confuser 8
Lightweight laminate 10
Brake with a brain 12
Manmade diamonds 12
Seagoing hydraulics 14
Photographic memory 28
Thirty-pound gas turbine .. 30
Bargain-priced reactor 30
Cessna retractable gear 33
Data searcher for metals .. 34
Project ORCON 36
NBS studies rust 41

Trends 22
Meetings and Shows 42

Scanning the Field for Ideas 116

Torsion-bar twist on split gear eliminates backlash in gear train—pneumatically positioned pivot arm actuates switches in sequence—split gland provides two-way seal for drive screw—crimped splices prevent air leakage through electrical connections.

Design in Action 138

Stationary cam programs merry-go-round capper—gears synchronize three hands and worktable of ring-rolling machine—self-correcting servo loop guides plotter for equal-intensity curves.

Tips and Techniques

Constructing ellipses 131

Design Abstracts 159

New Parts and Materials 174

Engineering Department Equipment 209

The Engineer's Library 212

Noteworthy Patents 216

Backtalk 232

Helpful Literature 170

Subject Index 17
Reader Service Cards ... 19
Advertising Index 231
Business Staff 231

IN THE NEXT ISSUE: Profile of an engineer . . . an 1889 position servo for guns at sea . . . hot and cold malleable iron . . . mobility method of dynamic analysis . . . sleeve bearing fabrication and assembly . . . wiping seal design for sealed bearings . . . graphic linkage design . . . stress and deflection in shafts

Editor
COLIN CARMICHAEL

Associate Managing Editors
BENJAMIN L. HUMMEL
ROBERT L. STEDFELD

Associate Editors
LEO F. SPECTOR
ROBERT C. RODGERS
WILLIAM S. MILLER
SPENCER R. GRIFFITH

Assistant Editors
CLARE E. WISE
JAMES A. PARKS
THEODORE M. LEACH
STANLEY G. COOK
RICHARD A. JACOBSON
KENNETH J. REHOR
JANE H. SMITH
MARIAN L. EICHAR

Art Editors
FRANK H. BURGESS
ROBERT L. TUFTS

Contributing Editor
ROGER W. BOLZ

EDITORIAL OFFICES
Penton Building, Cleveland 13, Ohio

Branch Offices
New York, Detroit, Chicago, Pittsburgh, Washington, London

MACHINE DESIGN is sent at no cost to management, design and engineering personnel whose work involves design engineering of machines, appliances, electrical and mechanical equipment, in U. S. and Canadian companies employing 20 or more people. Copies are sent on the basis of one for each group of four or five readers. Consulting and industrial engineering firms, research institutions and U. S. government installations, performing design engineering of products are also eligible.

Subscription in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $25. When requesting changes of address, etc., please allow four to six weeks for processing.

Published every other Thursday and copyrighted 1959 by The Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.

How B&W JOB-MATCHED TUBING helps you design a better end product

You can get the right tube for your job with B&W Seamless Mechanical Tubing because you can choose from:

- ...a range of sizes, grades, and finishes for design flexibility
- ...a variety of heat treated conditions for the most suitable mechanical properties
- ...special shapes and prefabricated forms to improve design and simplify production.

These are just some of the reasons it pays to specify B&W Job-Matched Mechanical Tubing. Call your local B&W District Sales Specialist, or write for Bulletin TB-361 for full information. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pennsylvania.

B&W

THE BABCOCK & WILCOX COMPANY

TUBULAR PRODUCTS DIVISION

TA-9009-SM4

Seamless and welded tubular products, solid extrusions, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels and special metals

ENGINEERING NEWS

Data Survey Highlights Engineering-School Problems

Teachers Becoming Scarce; More Students Taking Science

WASHINGTON—Latest round of surveys, correlated by the Engineers Joint Council and the Scientific Manpower Commission, points out problems don't seem to be improving in engineering schools: More students are going into the sciences; professors are getting scarce; graduating classes are apparently going to stay about the same size, at least for the next two years.

Engineers Lost to Science?

More college juniors are majoring in science and math (10.4 per cent more during '58-'59 than during '57-'58). Fewer juniors are going into engineering (down 2.5 per cent). The junior body is now made up of 13.8 per cent math and science majors, only 11.7 per cent engineering majors.

Other facts brought out (in a survey conducted by the Government's Office of Education): Almost one-third of junior men are majoring in science or engineering; mathematics is the fastest growing field (a 31 per cent increase); physics jumped 10.9 per cent; chemistry rose only 3.2 per cent during a year that saw 3.8 per cent more juniors.

Teacher Shortage . . . Unchanged

Professional personnel needs of colleges are still critical, according to a National Education Association survey. Demand for teachers has increased 100 per cent in the last six years, and the preparation level of those hired has decreased alarmingly. The shortage continues. About one-third of the new teachers filled engineering and science vacancies. Only 23.8 per cent of this group had earned Doctor's degrees, and 23.8 per cent had less than a Master's degree.

New Alloy Gives the Vigilante a Tough, Thin Skin

Weight of the Navy's hottest attack bomber is cut significantly by the use of a new lithium-aluminum alloy. North American Aviation covers the A3J Vigilante with 4200 lb of X2020 sheet (developed by Aluminum Co. of America) to effect a 3 per cent (168 lb) savings in skin weight. Lithium gives the new alloy a modulus of elasticity 8 per cent greater than standard aircraft aluminum alloys, which means that Vigilante's skin can be proportionately thinner—thus lighter in weight. Use of X2020 on the A3J represents the alloy's first aircraft application.

Instruction in mathematics has suffered: 34.2 per cent of mathematicians hired in '53-'54 were Doctors; only 20 per cent of those hired in the past year had reached this level.

Half the schools responding to the survey had unfilled teaching positions; half the jobs open were in engineering schools. Salary increases and new fringe benefits are being used to attract new teachers and hold old ones, and new faculty members are brought in at higher rank. Many of the new professors are not as well qualified as the colleges would desire. Overlapping courses and small classes were eliminated, as were refresher and sub-college courses offered to students not adequately prepared.

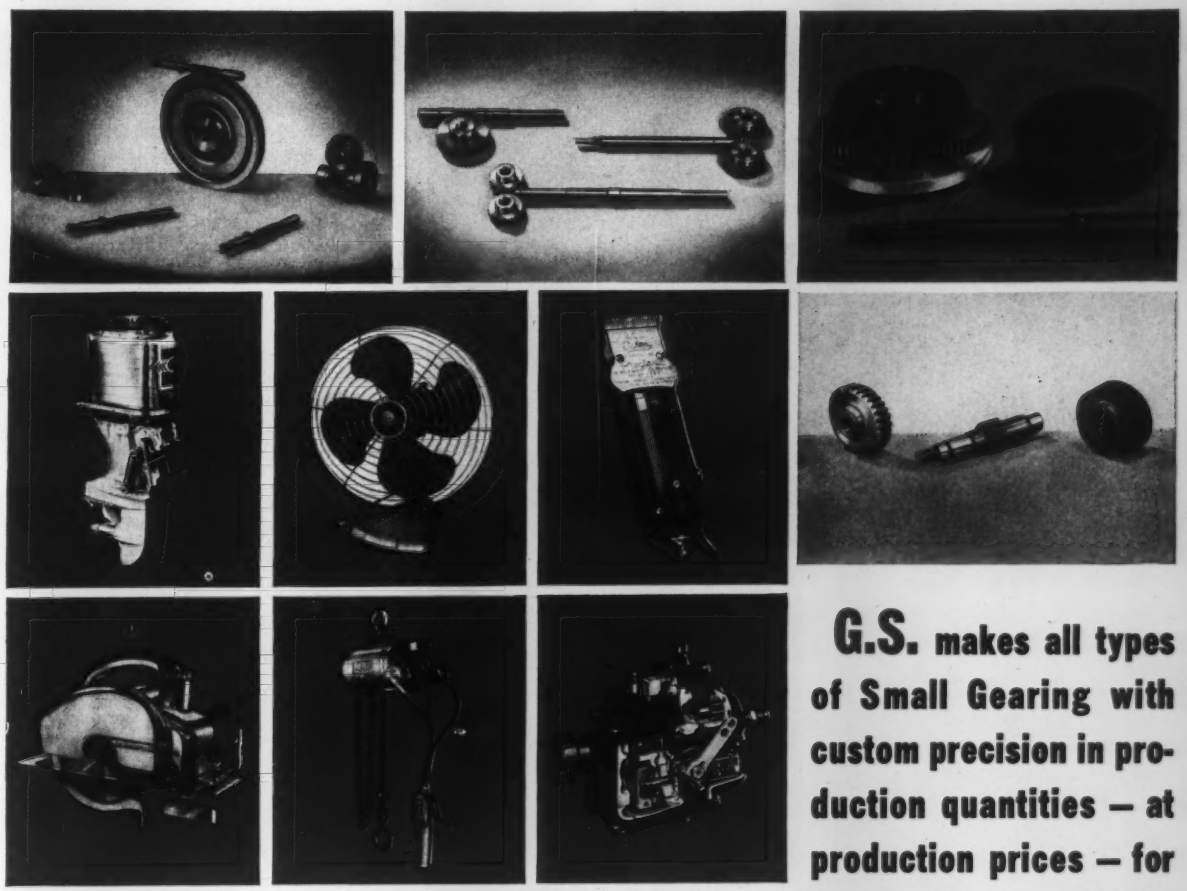
Degrees in '60

According to the U. S. Office of Education, the 1959 graduating class (close to 38,000 engineers) started with 72,825 freshmen. Although the 1960 class started larger (77,738 freshmen), the graduating class will apparently be smaller (37,415 projected). Within the past five or six years, the trend in degrees by curricula distribution has shown: Electrical gaining steadily (now 27 per cent); Civil dropping (15 per cent). Mechanical, Chemical, and Industrial are remaining fairly constant.

Numbers of Engineering Grads*

Curriculum	1958	1959	1960
Aeronautical	1188	1300	1285
Agricultural	359	360	350
Chemical	2920	3025	2975
Civil	4673	5050	4975
Electrical	8712	9500	9400
General	683	710	685
Industrial	1783	1875	1825
Mechanical	7859	8425	8350
Metallurgical	662	680	670
Mining	220	205	190
Petroleum	680	685	660
All Others	1477	1800	1750
Total	31,216	33,615	33,115

*From ECPD accredited colleges.



G.S. makes all types of Small Gearing with custom precision in production quantities — at production prices — for

Appliances • Electrical Motors • Computers • Missiles • and all critical requirements

FRACTIONAL HORSEPOWER GEARING

GEAR Specialties, Inc.

2635 WEST MEDILL AVENUE
CHICAGO 47, ILLINOIS

SPURS • SPIRALS • HELICALS • BEVELS • INTERNALS
WORM GEARING • RACKS • THREAD GRINDING

WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF FRACTIONAL HORSEPOWER GEARING

Have you been penalizing yourself with short-run production — at short-run high cost — to get the custom precision you require for an especially difficult, especially complex power transmission problem? Then G.S. has a lot to offer you.

Because they know that G.S. does much more than just "make Gears," a long list of leaders in a dozen major industries — and hundreds of smaller but mighty important producers of quality units — have for many years depended on G.S. ability, G.S. experience and G.S. performance to supply all or the major part of their Small and Intermediate Gearing requirements.

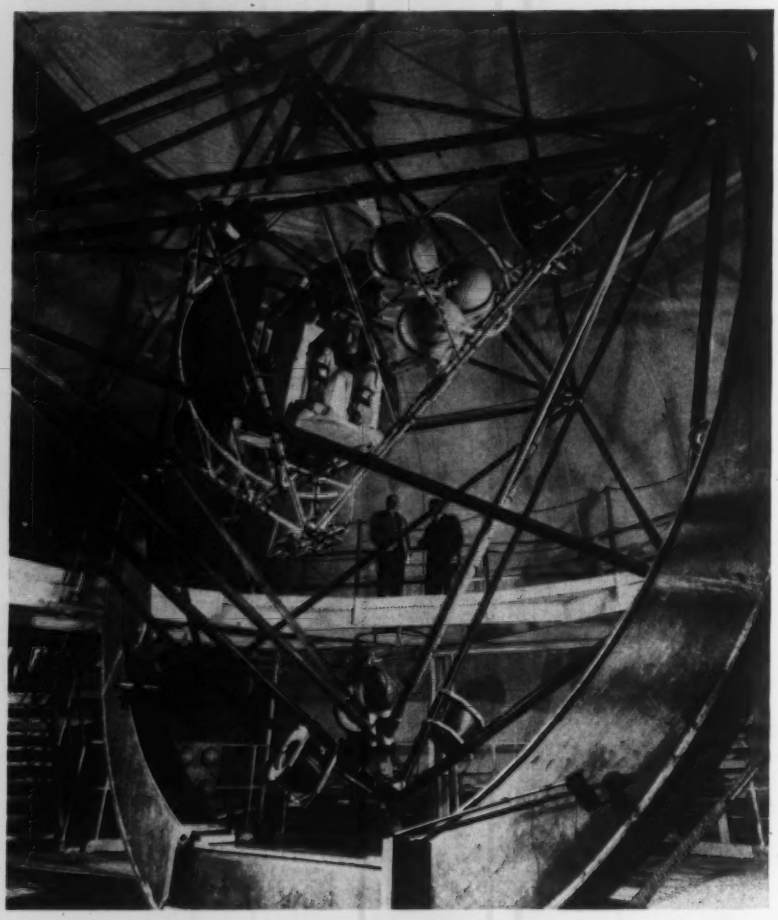
If you need Small or Intermediate Gears of any type, made to meet high-precision specs, G.S. can do more for you, too — whether it's a matter of developing better methods of power transmission for new projects, or improving performance and costs on old ones. Our engineers are at your service — call or write us today.

SEND FOR G.S. ***illustrated folder! See where and how we mass-manufacture Small Gearing to uniformly fine tolerances. Folder contains 23 pictures of Small Gears, plant view, as well as Diametral and Circular Pitch Tables. Ask for your copy on company stationery, please!***

43 Years of Specializing in Small Gearing!

Circle 407 on Page 19

Astronaut Confuser



Spin tests in NASA's three-gimbal capsule simulator will subject Project Mercury astronauts to disorienting motions of space travel. Capsule, mounted in the inner cage, rotates about three axes at speeds ranging to 50 rpm.

CLEVELAND—A space cabin mock-up mounted inside three gimbal cages will give Project Mercury astronauts a whirling preview of their impending flight in space. The complex rig, known as MASTIF (Multiple Axis Test Inertial Facility) is located at NASA's Lewis Research Center, Cleveland. It simulates all possible attitudes of space flight—yaw, roll, and pitch.

The capsule mock-up is complete with a life-support couch for the pilot. Even the "guidance" is realistic: Small reaction motors, emitting spurts of nitrogen gas, control the gimbals. Attitudes of the capsule are controlled by scientists directing the "flight," or by the pilot himself using wrist-action controls.

Two phases of the program are now nearing completion. In the first, the pilot is blindfolded and asked to identify movements of the capsule on each axis. In the second phase, the pilot attempts to control the attitude of the capsule while the gimbals revolve at 20 rpm.

Later experiments will be made at speeds higher than 20 rpm, and pilots will attempt to fly the rig by instruments. In the final workout, a visual reference system will be substituted for instruments. This will show the earth and stars as the astronaut would see them at an altitude of 100 miles.

Preliminary test results show that pilots can immediately counteract disorientation on any one axis. Some delay is noted, however, in reactions to simultaneous movements on all three axes at speeds of 20 rpm—which seems reasonable.

Topics

A machine that reads writing, developed by Bell Telephone Laboratories, has a limited vocabulary but is called an "early experimental step" in the study of how such machines can be made. It can read handwritten numbers zero to nine by picking out features of the overall shape of the word, such as ascenders, descenders, and dots on the letter *i*.

• • •

Modern Socrates is the role assigned to a school teacher by new tutoring machines. According to Dr. Finley Carpenter, assistant professor of education at the University of Michigan, these machines can take over the job of instruction, do it more efficiently, and allow teachers to help students learn to evaluate themselves. A tutoring machine is a subtle instructor—it confronts the student with a task well within his ability to perform, then increases the difficulty of succeeding tasks so that the student soon exceeds his original performance level. Dr. Carpenter predicts that—perhaps within five years—machine learning will be common.

• • •

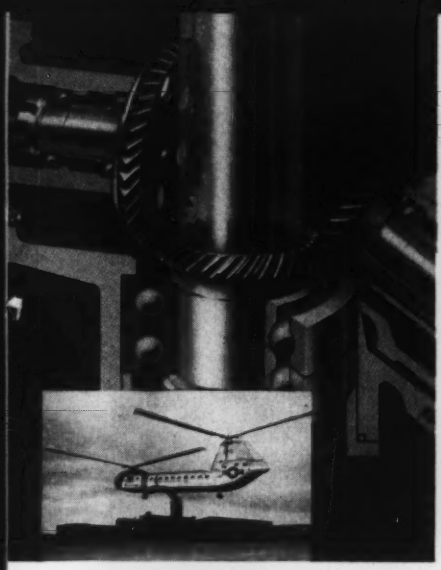
A very primitive product was put to modern use recently at a gas conservation plant in Canada. In the flare tower, where excess gas is burned off, the flame went out, and the mechanical relighting device failed. The company summoned an archer who shot a flaming arrow into the air and relit the flame.

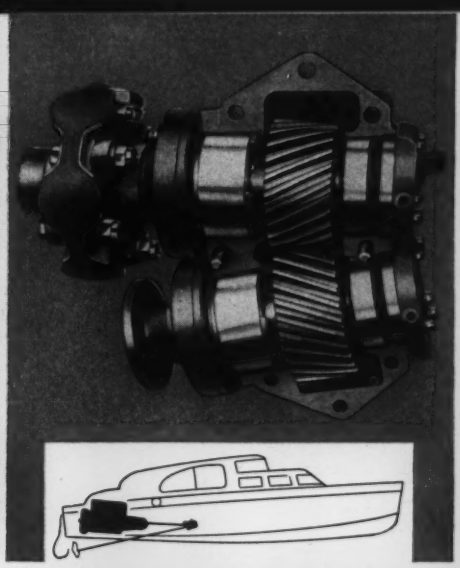
• • •

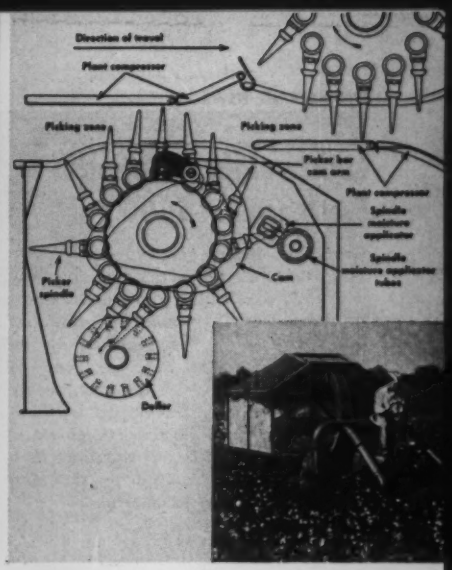
Underground H-bomb explosions may provide a cheap source of power. Several experimental explosions have shown that huge cavities can be formed deep in the earth which will contain heat released from the explosions and which can be supplied with water to produce high-pressure, high-temperature steam. A five-megaton bomb, carrying a price tag of $1 million including safety studies, placement, and detonation, can produce thermal energy at a rate of five cents per million Btu. Still lower costs for higher output nuclear devices are predicted.

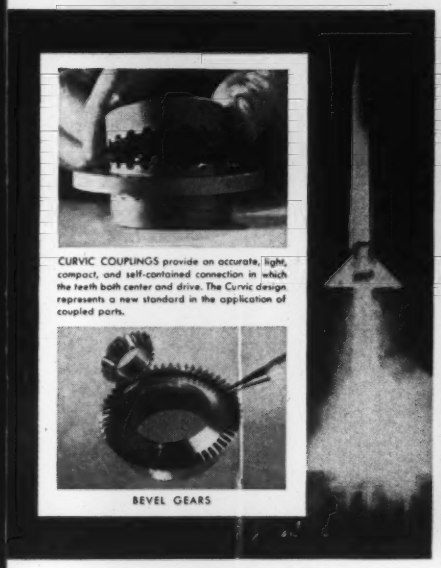
• • •

Real economy car engine, a Russian claim, runs on any kind of fuel, including oil cracking wastes and natural gas. The engine reportedly gives five to seven times the power of a similar sized gasoline model, even on the lowest grades of fuel. Also, combustion is so complete that almost no exhaust gases are produced.



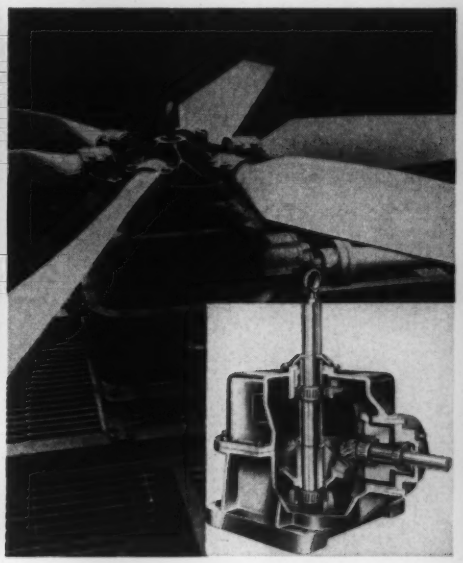


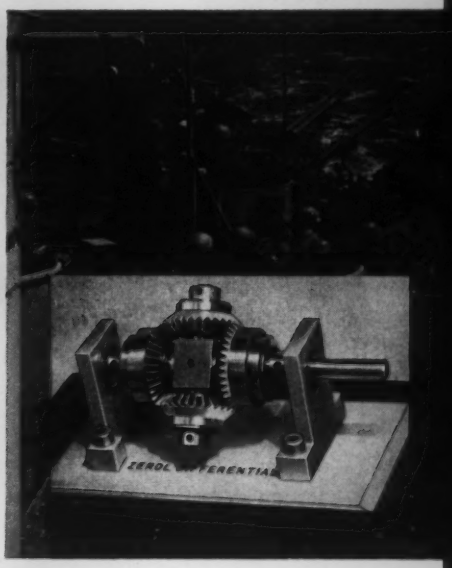




CURVIC COUPLINGS provide an accurate, light, compact, and self-contained connection in which the teeth both center and drive. The Curvic design represents a new standard in the application of coupled parts.

BEVEL GEARS





What happens when you use right angle or angular drives?

More flexibility. Instead of designing *around* your transmission, you can design a transmission *into* your products with angular drives.

The *helicopter*, for example, is made more compact by having a single drive source service both a blower and a pump. The drive on the *speedboat* gives better balance and more usable cabin space. The *cotton picker* runs fourteen separate picking spindles off one drive member.

Greater accuracy. Using Gleason machines and methods you can grind or cut bevel gears to exceptionally close tolerances. The complete accuracy and reliability needed in the *missile* and *fire control unit* are obvious.

Heavier loads. An angular drive can stay compact and still carry heavy loads such as the one on the gear reducer in the *cooling tower fan*.

Full engineering help. A large and competent staff of Gleason engineers is yours to call on for help in early design work, for the manufacture and testing of prototypes, for selecting and setting up of machines and methods, and for any other assistance you might need.

Free literature. To become better acquainted with the advantages and the theory of bevel gear drives, send for these Gleason Manuals:

20° Straight Bevel Gear System
Spiral Bevel Gear System
Zerol® Bevel Gear System

GLEASON WORKS

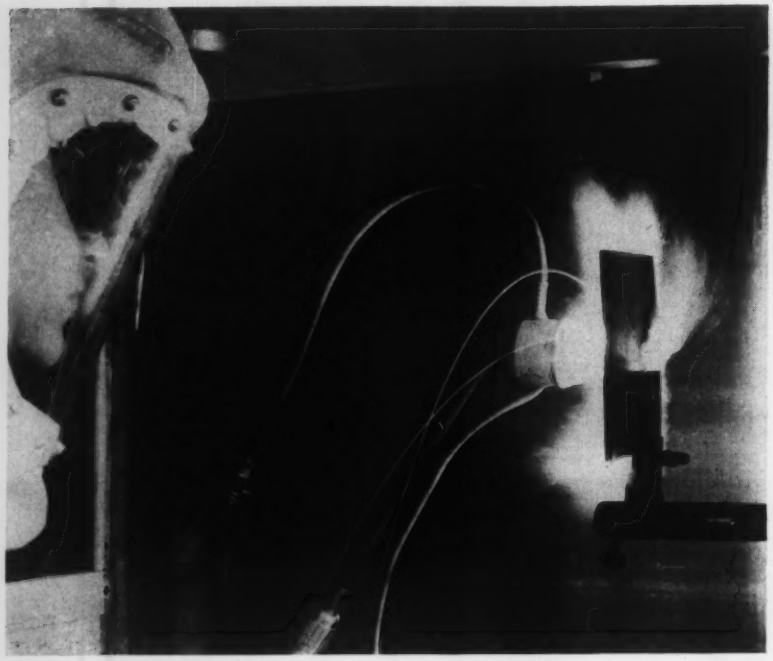
1000 UNIVERSITY AVE., ROCHESTER 3, N. Y.

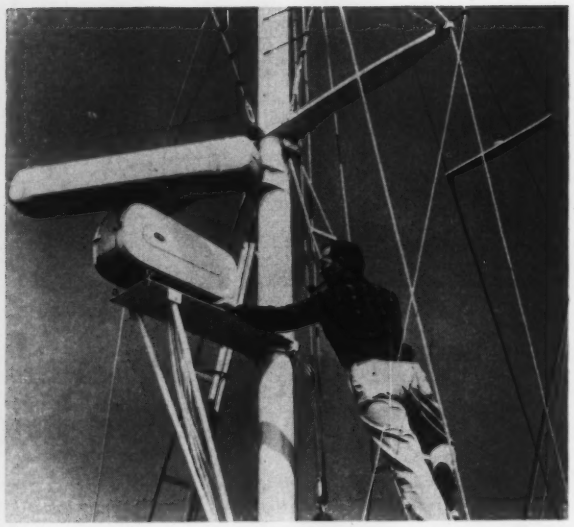
Circle 408 on Page 19

Lightweight Laminate Withstands 5000 F

Graphite fabric impregnated with phenolic resin forms a promising new material for ultrahigh-temperature applications. In laboratory ablation tests, a 0.25-in. thick sample of the new laminate has been exposed to 5000-F flame for 10 minutes before burning through. Developed by Continental Diamond Fibre Corp., Newark, Del., the material is still classified as a development item. Other physical and electrical characteristics are:

Thickness (in.)	0.131
Tensile strength (psi)	
Lengthwise	13,000
Crosswise	10,000
Flexural strength, flatwise (psi)	24,900
Impact strength, edgewise,	
Izod (ft-lb/in. notch)	1.12
Dielectric strength, perpendicular,	
short-time (v per mil)	7
Compressive strength (psi)	34,400
Hardness, (Rockwell M)	117





New Eyes for Pleasure Boats

New safety and navigational instruments for amateur boatsmen include a low-priced radar and a depth sounder (fathometer). Designed by Raytheon Co., Waltham, Mass., the equipment is reported to contain many features not before available in units priced for sportsmen. Radar indicator (above left) uses a 7-in. cathode ray tube and four signal scales: ½, 2, 6, and 12 miles. It is positively synchronized with the antenna, assuring accurate bearing information. Antenna (above right) is a double-banked waveguide 4 ft wide. The outgoing radar beam is only 2 deg wide, so that fine detail and definition can be obtained even when a small harbor buoy is the target. The depth sounder (right) bounces ultrasonic signals off the bottom of the lake under the boat. Returning echoes signal a flash on the indicator face. Depths to 120 ft are accurately reported. Character of the flashing signal tells the boatsman whether the bottom is sand, rock, or mud. Fish show as extra flashes on the scale.

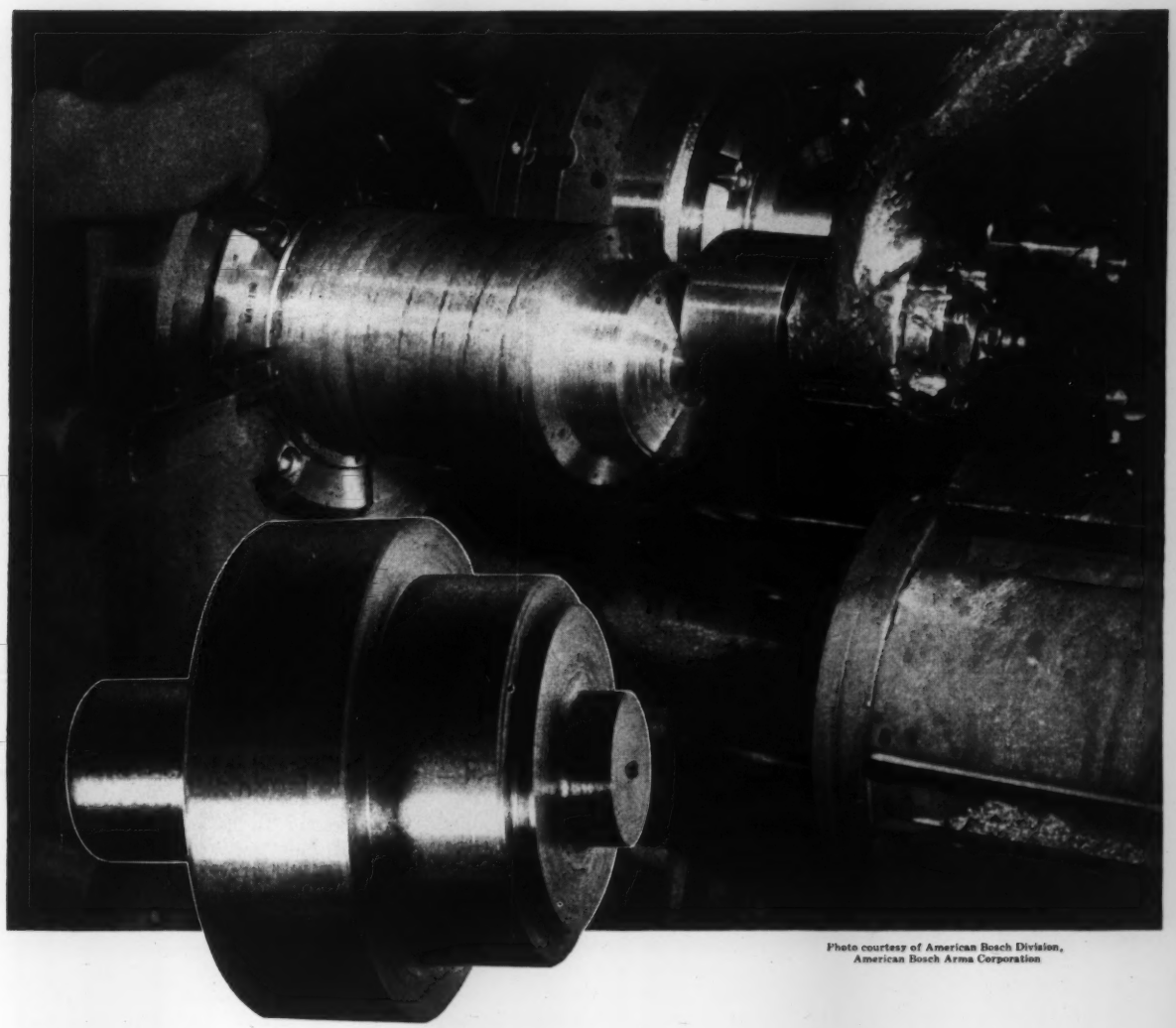


Photo courtesy of American Bosch Division, American Bosch Arma Corporation

Leaded Nitralloy Takes a Big Bite Out of Machining Time!

By switching to Nitralloy Leaded for this hydraulic head, secondary lathe operations and expensive heat treatment were completely eliminated. Produced in a single machining operation, the part is now sent directly to the grinding department. Spindle speeds and feeds were also increased.

For complete information about other fast-machining Aristoloy leaded steels or standard carbon, alloy and stainless grades, call the Copperweld representative in your nearest large city. Or write for booklet entitled, "A Complete Line of Leaded Steels," and NEW PRODUCTS & FACILITIES CATALOG.

ARISTOLOY STEELS

COPPERWELD STEEL COMPANY

ARISTOLOY STEEL DIVISION • 4017 Mahoning Ave., Warren, Ohio • EXPORT: Copperweld Steel International Co., 225 Broadway, New York 7, N. Y.

Circle 409 on Page 19

Brakes with a Brain Will Stop New Jet Liner

Unique Antiskid System Controlled by Computer

BURBANK, CALIF.—Although antiskid braking is nothing new on aircraft, a modulated system accepted for use on Convair's forthcoming 600 jet transport ranks as a major improvement in the field. Developed by Hydro-Aire Co., Burbank, Calif., it uses an analog computer to meter braking pressure in proportion to wheel slip. Conventional "on-off" antiskid systems merely release and reapply brake pressure as the wheel tries to slip.

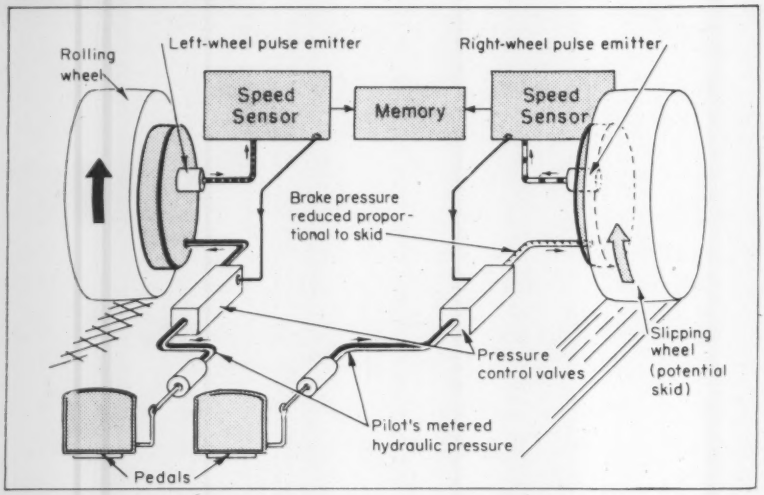
The proportional system is expected to eliminate "resonant gear walking"— a condition imposed by high landing speeds and the resulting deflection of landing gear as the brakes are applied. On-off brakes often aggravate the condition by cycling at the natural frequency of the gear.

Key components in Hydro-Aire's new system are an analog computer, pulse emitters for each wheel, and a pressure metering valve for each braked wheel.

Pulse frequency, related to wheel speed, is the computer input. As wheel speed changes, one electronic circuit for each wheel follows the change, while a common memory circuit follows the speed of the fastest rolling wheel. As long as no difference exists between these two circuit voltages, no current flows to the control valve. When a difference is detected, current is sent to the valve to reduce metered pressure on the skidding wheel. This current is proportional, but not linear, to the difference.

According to Hydro-Aire, brake pressure should vary nonlinearly to "full off" at approximately 25 per cent slip. Actual values and relationships, however, are set up to match the requirements of specific aircraft.

A lock-wheel circuit in the system prevents application of brake pressure to the wheels before touchdown or to any wheel that is bouncing after touchdown. Even if the pilot lands with his feet on the brake pedals, the wheels are not locked. A fail-safe circuit returns brakes to normal control in event of component failure.



Heart of the proportional braking system is a transistorized analog computer (speed sensors and memory). The computer detects any reduction in wheel speed and varies the ratio of brake pressure to pilot's brake-pedal force to control wheel slip. Convair's 600 jet transport will be one of the first aircraft fitted with the new system.

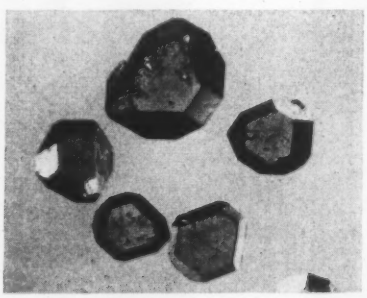
Molten Metal Is Catalyst in Diamond-Making Process

High Temperatures, Pressures Transform Carbon to Diamond

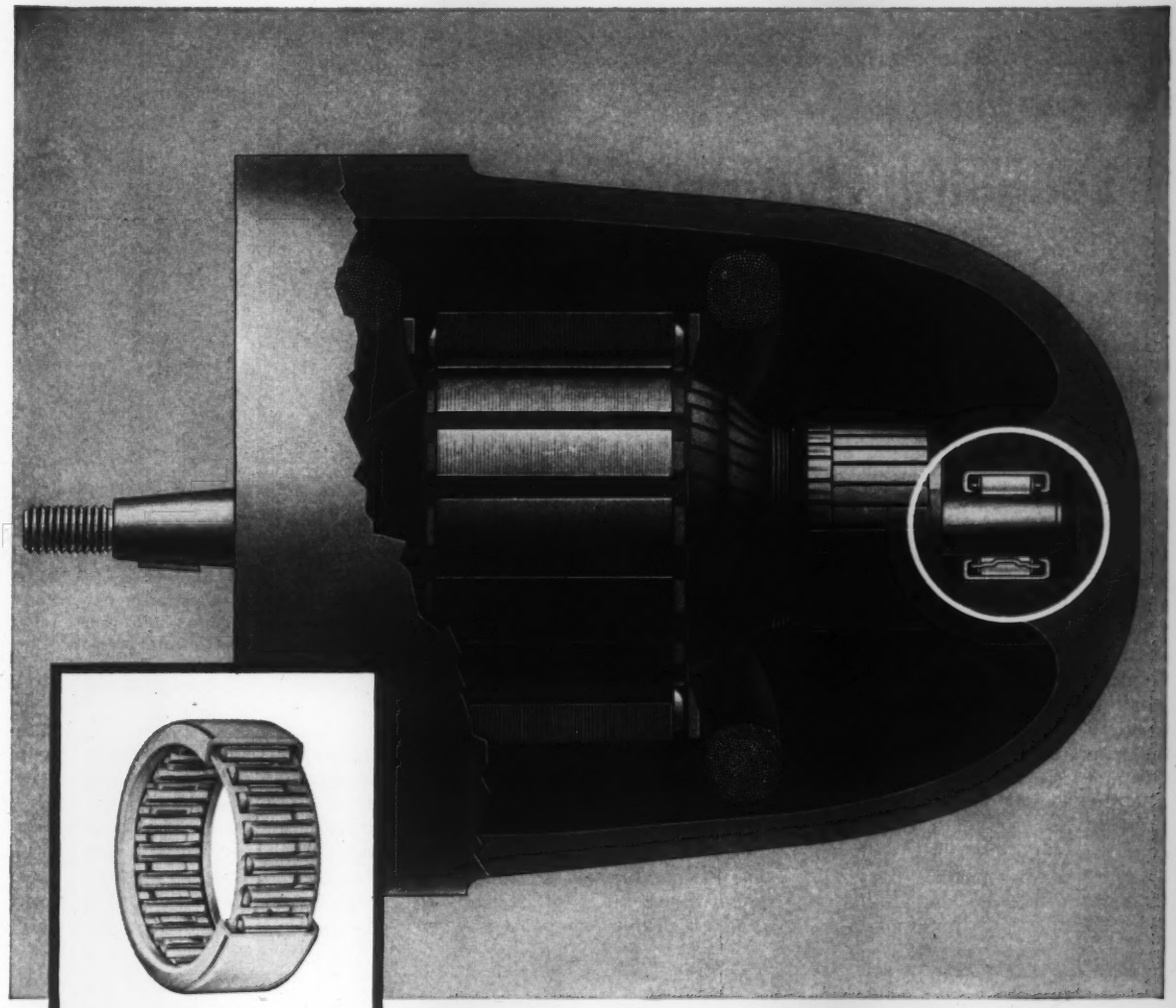
SCHENECTADY, N. Y.—Nature needs pressures of 3-million psi and temperatures of more than 7000 F to transform carbon to diamond. But nature doesn't use a catalyst. For four years man has been doing the same job at half the pressure and temperature.

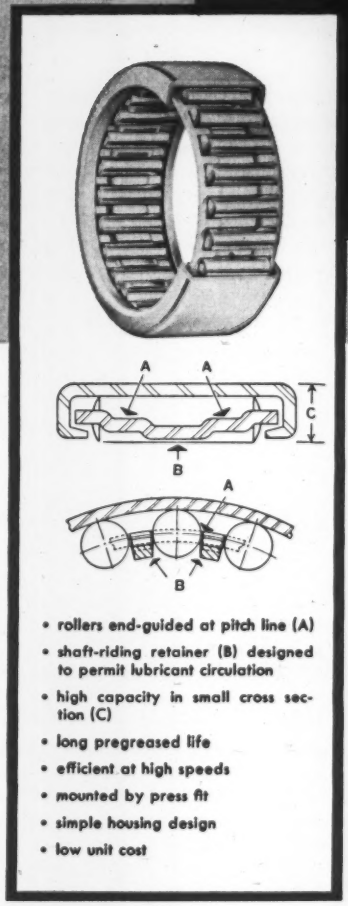
Because the Government has lifted a secrecy order, General Electric scientists are now able to talk about their technique. A molten-metal catalyst acts as a thin film between the carbon and the growing diamond crystal. Carbon and catalyst are placed in a pressure cell and subjected to pressures from 80,000 to 1,800,000 psi; temperatures range from 2200 to 4400 F. Number and kind of diamonds produced depend on the carbon source —graphite is best, but carbon black, sugar charcoal, or carburizing compound may also be used. The catalyst can be heavy metals like chromium, manganese, iron, cobalt, nickel, platinum. Tantalum is particularly effective for inducing growth of small crystals.

Diamond crystals form whether diamond "seeds" are present or not, and they grow at fast speeds: 80-mesh or finer stones form within a few minutes. The man-made diamonds in industrial use have proved superior to natural diamonds in vitreous as well as resin-bonded wheels. This is due to close control of the shape and other characteristics (lattice structure depends on formation temperature). It is possible to tailor the diamonds to industry's demands.



Man-made diamonds vary in both color and crystal structure, depending on formation temperature. Black, cubic-lattice diamonds are formed at the low end of the critical temperature range. Yellow and white octahedra predominate when formation temperature is at the high end of its range.





- rollers end-guided at pitch line (A)
- shaft-riding retainer (B) designed to permit lubricant circulation
- high capacity in small cross section (C)
- long pregreased life
- efficient at high speeds
- mounted by press fit
- simple housing design
- low unit cost

Save up to 50%
on armature bearing costs!

Low unit cost of the new Torrington Drawn Cup Roller Bearing reduces armature bearing cost as much as 50%. This unique bearing gives excellent service at high speed and permits prelubrication for life.

Test installations and service applications show the bearing performs efficiently at speeds up to 25,000 rpm in intermittent service of 1000 hours and more. In such service, initial lubricant lasts the life of the motor. Most applications require no seals. This, with the simplicity of housing design, contributes further to economy.

Designers are invited to evaluate the Torrington Drawn Cup Roller Bearing for such applications as generators, power tools, electric mixers, vacuum cleaners and other appliance motors where considerations of cost, speed, efficiency and light weight are paramount.

Services of Torrington's engineering staff are offered to assist you in design developments of every type of electric motor. **The Torrington Company, Torrington, Conn.—and South Bend 21, Ind.**

TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

NEEDLE • SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • BALL • NEEDLE ROLLERS • THRUST

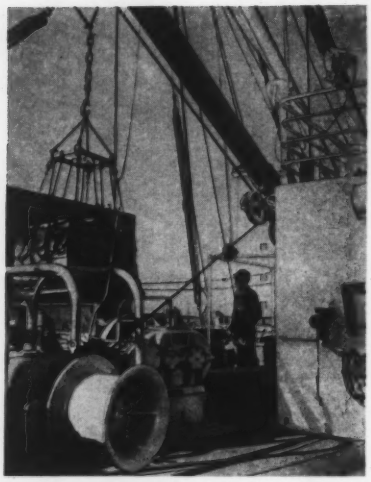
Circle 410 on Page 19

Top designers look at marine automation:

Vickers holds first conference on

Seagoing Hydraulics

NEW YORK—Faster turn-arounds and more trips per season—operating goals for any money-making merchant vessel—offer convincing arguments for use of hydraulics on shipboard. Performance and problems of such seagoing fluid-power systems were key topics at Vickers' first Marine and Naval Hydraulics Conference, convened earlier this month before a fair sampling of the nation's top ship designers, builders, and operators. Co-moderated by Park Adair (J. J. Henry Co.) and Capt J. M. Reigart (Bureau of Ships), the conference highlighted the dual role ("muscle" plus control) of hydraulic machinery in updated naval and merchant fleets.



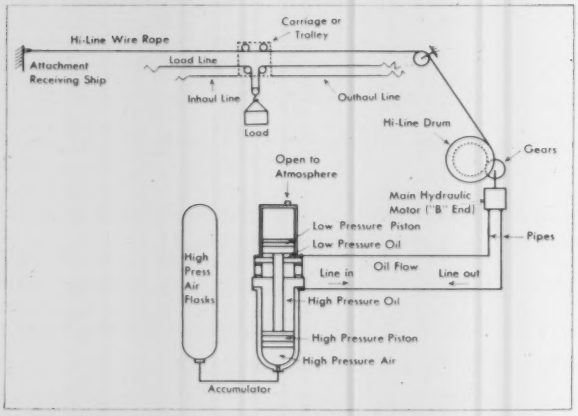
Fringe benefit for S. S. Argentina's electro-hydraulic winch is a substantial saving in ship's fuel oil during port-side loading operations. On conventional d-c ships, simultaneous operation of many winches forces generators into surges as high as 3000 amp. This, in turn, gives wide variations in governor travel and steam consumption.

Teammates: AC and Oil

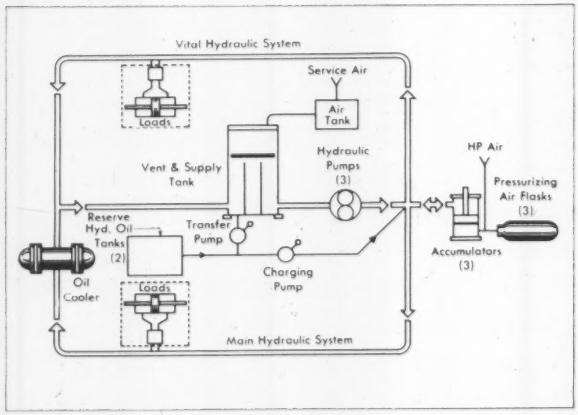
"We were not impressed by the prospect of having alternating-current ships with direct-current winches." This reservation led Moore-McCormack Lines to specify extensive use of hydraulic cargo-handling equipment aboard its new liners, *S. S. Argentina* and *Brasil*. In an appraisal of the ships, H. R. Glennon, M-M vice president, said also that reliability and flexibility of hydraulic-powered deck machinery (a-c motors teamed with oil drives) were key factors in permitting the vessels to operate on a tight schedule with minimum time in port. In making a plea for reduction in hydraulic-component cost, Glennon recommended that designers use standard industrial units where possible and combine complete systems in "packages" that can be mass produced.

Needed: Versatility

While admitting the versatility of "catalog" valves, actuators, and similar stock items, Western Gear's John Short said: "It is essential that the deck machinery designer not confine himself to mechanical design alone. He must be ready to design hydraulic components when necessary." Short's reasoning: Stock components don't always lend themselves to optimum design for single-purpose marine machinery. He also cautioned specification writers to become acquainted with the capabilities and limitations of hydraulics: "If an application does not



Ship-to-ship transfer of supplies and munitions is a tough assignment when seas run high. Older systems built up wild gyrations in the "high line," often dunked cargo (even admirals) in the brine. Navy's new automatic high-line and load-line tensioning winch uses the ships' motion to make a 75-hp motor do a 300-hp job. When receiver and supply ships roll away from each other, the main hydraulic "motor" acts as a pump, stores energy in the high-pressure accumulator. Energy is released and tension is restored in the high line when ships roll toward each other.



Submarine central hydraulic systems make ample provision for every possible emergency. This simplified circuit diagram (for USS Skipjack) shows the "vital system" that supplies essential sub control in an emergency. An isolated hydraulic pump and emergency electric-power source powers the vital system. Hand-operated charging pump (below vent and supply tank) also provides emergency power. Slow but handy during a deep-water crisis, the hand pump repeatedly charges the accumulators with oil and lets the high-pressure air drive oil into the hydraulic system.

utilize virtually the full capability of the smallest hydraulic package that will deliver the required performance, then cost of hydraulics can become substantially higher than competing equipment."

Navy's Convinced

N. E. Wenger, Supervisory Mechanical Engineer, Bureau of Ships, listed the advantages of oil hydraulics as the Navy sees them. His key points: 1. Stepless speed control. 2. High torque at low speeds. 3. Flexibility in component location. 4. High power-to-weight ratio. 5. Reliability. In comparing Navy vs. commercial marine component problems, Wenger said the Navy places heavier emphasis on resistance to mechanical shock and vibration.

Silent Service

Describing the role of hydraulic "muscles" in ship motion control (steering and roll stabilization), F. B. Brand, Sperry Piedmont Co., pointed out that in recent years, submarine controls have almost exclusively employed constant-pressure supply systems. However, he called variable-delivery pump systems "more efficient, more economical, and in general, more reliable. If the variable delivery pump is quieted, it will probably again be employed for submarine service."

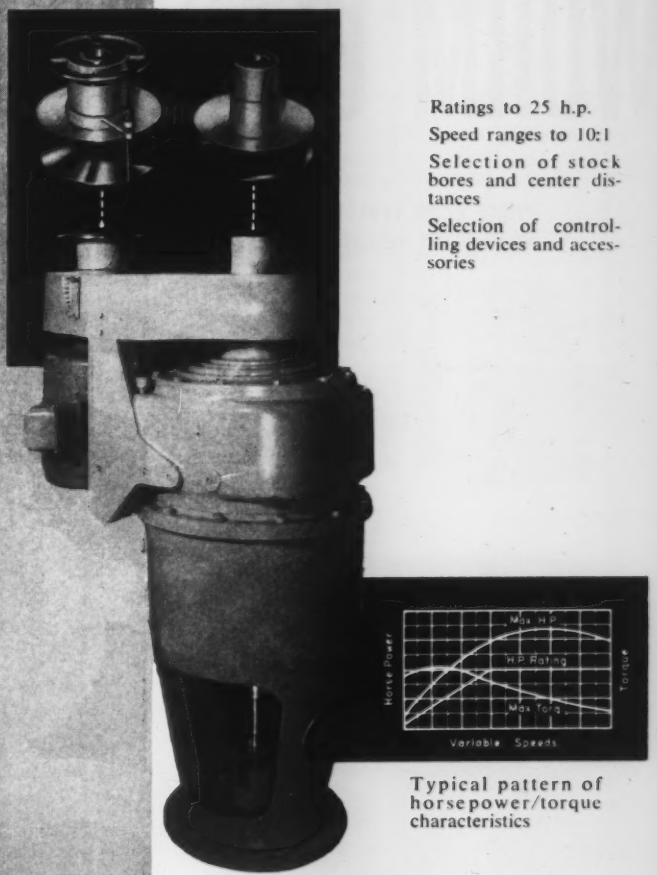
In other agenda items, Vickers' technical personnel briefed conference attendees on new thinking, new products, and recent progress in fluids, pumps and motors, applications, valves and controls, and techniques for effective maintenance.

Membership in ICI Offered To Investment Casting Users

Users of investment castings are eligible for a new category of membership in the Investment Casting Institute. Allied Membership, on a company or an individual basis, is offered only in firms not qualified for regular membership. Allied members will be eligible to attend all technical meetings, participate in ICI's Intra-Industry Research Program, work on technical committees, and participate in study groups. Interested companies can contact the Institute at 2 E. Monroe St., Chicago 3, Ill.

LEWELLEN

COMPONENTS INCORPORATE VARIABLE SPEEDS



Ratings to 25 h.p.

Speed ranges to 10:1

Selection of stock bores and center distances

Selection of controlling devices and accessories

Typical pattern of horsepower/torque characteristics

The shaft of a standard motor and the equipment input shaft mount the drive.

With an 1800 r.p.m. motor, any input speed from 500 to 4000 r.p.m. is available.

Handwheel adjusts speeds while running, without altering shaft center distance.

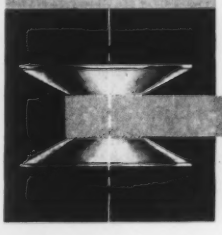
Shaft and bearing loads are normal. No thrust loads are imposed. No beefing or supporting structure is required.

Installation is quickly and easily made. Normal service requires only routine lubrication.

Sustained performance with overload capacity is obtained.

Lewellen Combination Pulleys offer a direct, compact, economical method for applying variable speeds.

Catalog 70 defines and dimensions the performance, convenience and utility of Lewellen Pulleys.



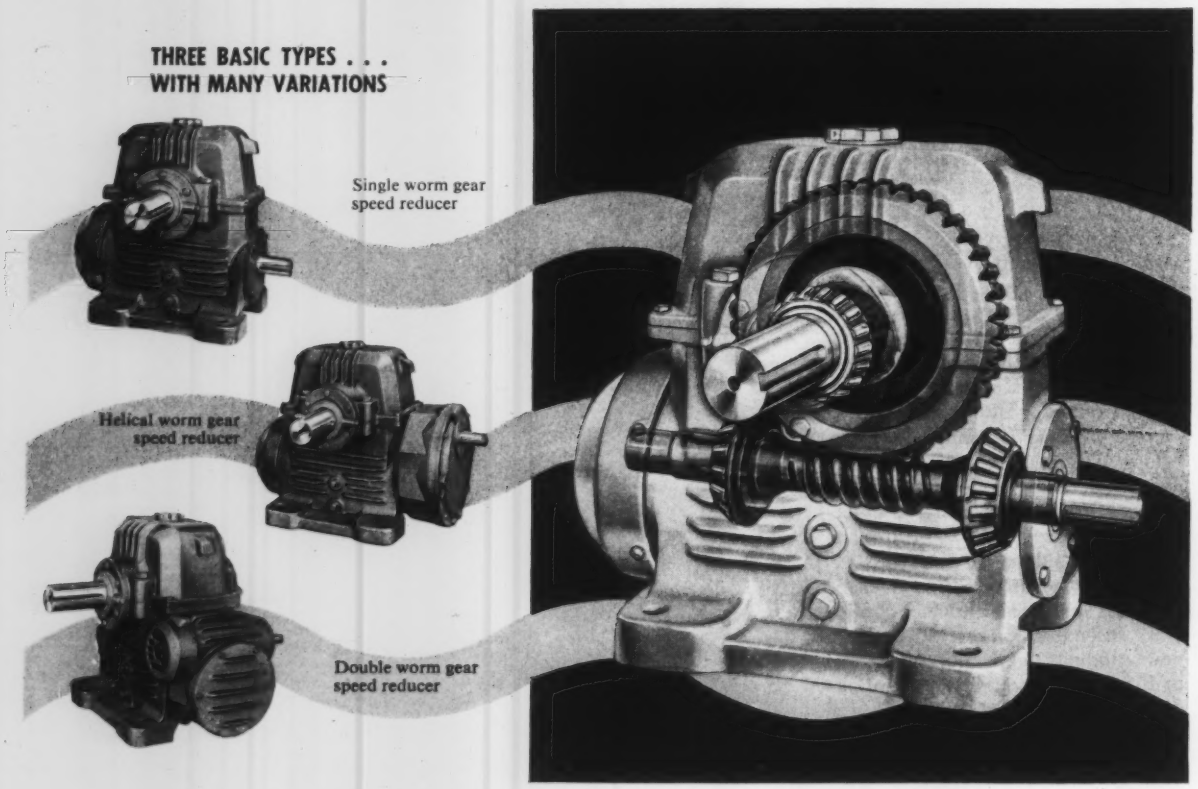
LEWELLEN

Manufacturing Company, Columbus, Indiana

Distributors in All Industrial Areas. In Canada—Peerless Engineering Sales, Ltd., Toronto-Montreal

NEW LINK-BELT FAN-COOLED WORM GEAR SPEED REDUCERS

**THREE BASIC TYPES . . .
WITH MANY VARIATIONS**



most complete line in industry

Industry's most complete line of worm gear speed reducers introduces more advanced refinements for reducing high motor speeds to requirements of modern production machines. Types and sizes for every right-angle need . . . single or double reduction . . . horizontal or vertical mountings . . . ratios from 5:1 to 3600:1, torque ratings up to 135,000 pound inches, up to 150 horsepower.

Compact, self-lubricated and fan-cooled, these units operate smoothly and quietly under high input speeds. Power is transmitted at either moderate or slow output speeds, with ample capacity for heavy loads. This all adds up to high ratings, maximum heat dissipation and minimum maintenance.

For complete information call your nearby Link-Belt office. Ask for Book 2824.

LINK-BELT
SPEED REDUCERS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 15.280

Reader Information Service

SUBJECT INDEX

Editorial and Advertising content classified by subject and listed by page number for convenience when studying specific design problems. For further information on subjects advertised, refer to advertisement and circle Item Number on a Yellow Card—following page.

Adhesives, Adv. 83
Airplanes, Edit. 33
Aluminum and alloys, Edit. 6; Adv. 93
Atomic reactors, Edit. 30

Bearings,
  ball, Adv. 21, 51, 192
  needle, Adv. 74
  roller, Adv. 13, 39, 51, 74, 104, 234
  sleeve, Edit. 132; Adv. inside front cover, 42, 64, 224
  thrust, Adv. 64
Bellows, Adv. 81
Belts, transmission, Edit. 188; Adv. 91
Blowers, Edit. 187
Books, Edit. 170, 172, 212; Adv. 7, 11, 35, 43, 48, 61, 62, 72, 74, 89, 101, 102, 106, 107, 108, 109, 110, 166, 184, 189, 190, 198, 204, 210, 214, 216, 218, 219, 221, 223, 225, 227, 228, 233, 234
Brakes, Edit. 12; Adv. 62, 165, 210, 227
Brass (see Copper and Alloys)
Bronze (see Copper and Alloys)
Bushings, ball, Adv. 206

Cabinets, Adv. 82
Camera, Edit. 164
Cams, Edit. 138
Carbides, cemented, Adv. 208
Carbon and graphite parts, Adv. 90, 178, 201
Castings,
  centrifugal, Adv. 157
  die, Adv. 196
  investment, Adv. 198
  iron, Adv. 45
  shell-molded, Adv. 157
  steel, Adv. 89, 157
Chain, transmission, Adv. 187, 190
Chopper, Edit. 205
Clamps, Adv. 87, 229
Classified ads, Adv. 176, 212, 230
Clutches, Edit. 177, 184, 218; Adv. 165, 169, 207, 210, 227
Coatings, protective, Edit. 22, 178; Adv. 84
Connectors, electric, Edit. 120, 177; Adv. 228
Contactors, Adv. 202
Controls,
  electric, Edit. 23, 117, 166; Adv. 72, 182, 197, 229
  hydraulic, Adv. 27, 222
  pneumatic blimp, Edit. 24
  pneumatic, Adv. 27
  temperature, Adv. 91
Copper and alloys, Adv. 31, 183
Corrosion, Edit. 41
Counters, Adv. 217
Couplings,
  fluid flow, Adv. 161
  shaft, Edit. 180; Adv. 100, 223, 229
Cylinders,
  hydraulic, Edit. 201; Adv. 219, 224
  pneumatic, Adv. 87, 109, 224

Diamonds, Edit. 12
Differentials, Adv. 225
Drafting equipment, Adv. 47, 50, 171
Drives, adjustable speed, Adv. 15, 54, 57

Electric equipment (see specific type)
Engineering department (see Management or Drafting)
Engines, Edit. 23; Adv. 105
Equations, Edit. 155
Extrusions, plastics, Adv. 93, 218

Fans, Adv. 167
Fasteners,
  bolts, studs, screws, Adv. 35, 80, 89, 168, 188, 221, inside back cover
  insert, Adv. 35
  nuts, Edit. 174, 190; Adv. 168, 173, 179, 221, 222
  pin, Adv. 227
  quick operating, Adv. 101
  retaining rings, Adv. 99
  rivet, Edit. 182; Adv. 101, 215
Feeders, parts, Adv. 87, 163
Filters, Edit. 184; Adv. 106, 213
Finishes (see Coatings)
Fittings, pipe, tube, and hose, Edit. 198, 218; Adv. 48, 61, 221
Forgings, Adv. 46, 93
Forming, Edit. 169

Gages, (see also Instruments)
  pressure, Adv. 92, 181
Gaskets, Adv. 110
Gear shaping, Edit. 140
Gears, Edit. 180; Adv. 7, 9, 95, 184
Glass, Adv. 189, 193

Heat exchangers, Adv. 164, 195
Heat-resistant alloys, Adv. 186
Hose, nonmetallic, Edit. 159
Hydraulic equipment (see specific type)

Instruments, Edit. 188, 197, 209; Adv. 92, 177, 181
Insulation, Edit. 203

Literature searcher, Edit. 34
Lubricants, Edit. 132, 187
Lubrication,
  equipment, Edit. 194; Adv. 191
  systems, Adv. 107

Magnesium and alloys, Edit. 206
Management, engineering, Edit. 6, 22
Meetings and shows, Edit. 42
Metals (see specific type)
Motors (electric)
  fractional and integral hp, Edit. 174; Adv. 1, 78
  gearmotors, Adv. 162
  subfractional hp, Edit. 182, 194; Adv. 98, 188
  torque motors, Adv. 108
Mountings, vibration and shock, Adv. 94

Nickel and alloys, Adv. 73

Oral reports, Edit. 163

Packings, Adv. 2, 44, 62
Photo elasticity, Edit. 143
Plate, identification, Edit. 174
Plastics,
  laminates, Edit. 10; Adv. 53
  molding, Edit. 152; Adv. 53, 62, 67, 185, 193, 200, 211
  reinforced, Adv. 53, 67
  shields, Edit. 22
Plugs, Adv. 228
Pneumatic equipment (see specific type)
Powder metallurgy, Adv. 84, 166

MACHINE DESIGN is indexed in Industrial Arts and Engineering Index Service, both available in libraries, generally

Power supplies, Edit. 210
Printed circuits, Edit. 174
Processing equipment, Adv. 77
Pulleys, Adv. 15, 43
Pumps,
hydraulic, Adv. 182, 199, 209, 214
pneumatic, Adv. 220

Radar, Edit. 10
Rectifiers, Edit. 206
Reducers, speed, Edit. 201; Adv. 16, 54, 60, 205, 221
Regulators,
pressure, Edit. 208
voltage, Edit. 202
Relays, Adv. 197, 219, 223, 225
Reliability, Edit. 112
Resistors, Adv. 223
Rubber, molding, Edit. 200; Adv. 62, 102, 211

Satellites, Edit. 8, 34
Sealants, Adv. 41, 83
Seals, Edit. 118, 119, 203; Adv. 2, 44, 191, 198
Servo plotters, Edit. 142
Shafts,
flexible, Adv. 219
torque, Edit. 216
Sheaves (see Pulleys)
Shims, Adv. 194
Small parts, Adv. 166
Solenoids, Adv. 227
Space travel, menus, Edit. 28
Springs, Edit. 220; Adv. 65
Steel, Adv. 11, 29, 68, 84, 186, 226, back cover
stainless Adv. 68, 97
Submarines Edit. 34
Switches, Edit. 181, 200, 205; Adv. 52, 72, 229
memory, Edit. 28
Swivel joints, Adv. 158, 224
Systems,
guidance, Edit. 36
hydraulic, Edit. 14; Adv. 175
lubrication, Adv. 76, 226

Telephone TV, Edit. 22
Testing, Adv. 103
Thermoelectricity, Edit. 23
Thermometers, Edit. 209; Adv. 92, 180
Tips and techniques, Edit. 131
Torsion bars, Edit. 116
Transformers, Edit. 198
Transmissions, adjustable speed, Adv. 175
Tubing, Edit. 190, 202; Adv. 5, 86, back cover
Turbine, gas, Edit. 30

Valves,
hydraulic, Edit. 174, 193, 197, 203, 208; Adv. 222, 226, 228
pneumatic, Edit. 174, 178, 208, 216; Adv. 216, 222, 226, 228

Welding, Adv. 32
Wheelbarrow, atomic, Edit. 36
Wire and wire products, Edit. 203; Adv. 75

USE A YELLOW CARD *for More Information . . .*

CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

Index to New Parts & Helpful Literature

BY ITEM NUMBERS

HELPFUL LITERATURE—descriptions start on page 170

	ITEM NUMBER		ITEM NUMBER
Motor Starting Relays	601	Molded Packings	618
Custom-Shaped Bars	602	Heat Resistant Castings	619
Free-Piston Pump	603	Hydraulic Pump	620
Plastic Moldings	604	Hose & Tube Fittings	621
Glass Fabrics	605	Process Control	622
Leather Packings	606	Heating Coils	623
Tube Fittings	607	Nylon Fittings	624
Pressure Reducing Valves	608	Magnetic Clutches	625
High Strength Steel	609	Electrical Contacts	626
Carbon Steel Bars	610	Thermostat Metals	627
Fluid Power Generators	611	Cold Heading Wire	628
Hydraulic Fittings	612	Solenoid Valves	629
Thyratron Controls	613	Pipe Thread Fittings	630
Air-Hydraulic Boosters	614	Air, Water & Oil Cylinders	631
Drafting Equipment	615	Pressure Vessels	632
Cooling Tower Drives	616	Instrument Counters	633
Valves & Fittings	617	Relay Testing Procedures	634

NEW PARTS & ENGINEERING EQUIPMENT—descriptions start on page 174

	ITEM NUMBER		ITEM NUMBER
Printed Circuits	635	Hysteresis Motor	659
Fractional-Horsepower Motor	636	Punched-Tape Reader Set	660
Miniature Valve	637	Ball Valves	661
Nut-Washer Combination	638	Pipe Fittings	662
Identification Plates	639	High-Temperature Transformer	663
Electrical Connectors	640	Synthetic Rubber	664
Miniature Slip Clutch	641	Footswitches	665
One-Package Coating	642	Reduction Drive	666
Solenoid Valves	643	Hydraulic Cylinders	667
Shaft Collars	644	Small Tubing	668
Spheroid Bevel Gears	645	Constant-Volume Regulator	669
Snap-Action Switches	646	Fastener Seals	670
Blind Rivets	647	Shielded-Wire Ferrule	671
Miniature DC Motor	648	Aluminum Wire	672
Precision Filter	649	Back-Pressure Valves	673
Face-Tooth Clutches	650	Limit Switch	674
Dry Lubricant	651	Transistor Chopper	675
PVC Blowers	652	Cold-Bending Sheet	676
Digital Display Unit	653	Silicon Power Rectifier	677
V-Belt Drives	654	Back-Pressure Regulator	678
Zippered Tubing	655	Spool Valve	679
Nylon Stop Nuts	656	Strain Gage	680
Gate Valves	657	Recording Thermometer	681
Air-Line Lubricator	658	Power Supplies	682

MACHINE DESIGN
NOV. 26, 1959

Circle item number for information on products advertised or described or copies of literature.

401	431	461	491	521	551	581	611	641	671	701	731	761	791	821	851
402	432	462	492	522	552	582	612	642	672	702	732	762	792	822	852
403	433	463	493	523	553	583	613	643	673	703	733	763	793	823	853
404	434	464	494	524	554	584	614	644	674	704	734	764	794	824	854
405	435	465	495	525	555	585	615	645	675	705	735	765	795	825	855
406	436	466	496	526	556	586	616	646	676	706	736	766	796	826	856
407	437	467	497	527	557	587	617	647	677	707	737	767	797	827	857
408	438	468	498	528	558	588	618	648	678	708	738	768	798	828	858
409	439	469	499	529	559	589	619	649	679	709	739	769	799	829	859
410	440	470	500	530	560	590	620	650	680	710	740	770	800	830	860
411	441	471	501	531	561	591	621	651	681	711	741	771	801	831	861
412	442	472	502	532	562	592	622	652	682	712	742	772	802	832	862
413	443	473	503	533	563	593	623	653	683	713	743	773	803	833	863
414	444	474	504	534	564	594	624	654	684	714	744	774	804	834	864
415	445	475	505	535	565	595	625	655	685	715	745	775	805	835	865
416	446	476	506	536	566	596	626	656	686	716	746	776	806	836	866
417	447	477	507	537	567	597	627	657	687	717	747	777	807	837	867
418	448	478	508	538	568	598	628	658	688	718	748	778	808	838	868
419	449	479	509	539	569	599	629	659	689	719	749	779	809	839	869
420	450	480	510	540	570	600	630	660	690	720	750	780	810	840	870
421	451	481	511	541	571	601	631	661	691	721	751	781	811	841	871
422	452	482	512	542	572	602	632	662	692	722	752	782	812	842	872
423	453	483	513	543	573	603	633	663	693	723	753	783	813	843	873
424	454	484	514	544	574	604	634	664	694	724	754	784	814	844	874
425	455	485	515	545	575	605	635	665	695	725	755	785	815	845	875
426	456	486	516	546	576	606	636	666	696	726	756	786	816	846	876
427	457	487	517	547	577	607	637	667	697	727	757	787	817	847	877
428	458	488	518	548	578	608	638	668	698	728	758	788	818	848	878
429	459	489	519	549	579	609	639	669	699	729	759	789	819	849	879
430	460	490	520	550	580	610	640	670	700	730	760	790	820	850	880

SEND COPIES OF FOLLOWING ARTICLES IN THIS ISSUE

Page No. Title of Article

....

....

....

....

CARD INVALID WITHOUT COMPANY NAME — TYPE OR PRINT

NAME _____

TITLE _____

COMPANY _____

PRODUCT MANUFACTURED _____

ADDRESS _____

CITY _____ ZONE____

STATE _____

Do not use this card after Feb. 26, 1960

MACHINE DESIGN
NOV. 26, 1959

Circle item number for information on products advertised or described or copies of literature.

401	431	461	491	521	551	581	611	641	671	701	731	761	791	821	851
402	432	462	492	522	552	582	612	642	672	702	732	762	792	822	852
403	433	463	493	523	553	583	613	643	673	703	733	763	793	823	853
404	434	464	494	524	554	584	614	644	674	704	734	764	794	824	854
405	435	465	495	525	555	585	615	645	675	705	735	765	795	825	855
406	436	466	496	526	556	586	616	646	676	706	736	766	796	826	856
407	437	467	497	527	557	587	617	647	677	707	737	767	797	827	857
408	438	468	498	528	558	588	618	648	678	708	738	768	798	828	858
409	439	469	499	529	559	589	619	649	679	709	739	769	799	829	859
410	440	470	500	530	560	590	620	650	680	710	740	770	800	830	860
411	441	471	501	531	561	591	621	651	681	711	741	771	801	831	861
412	442	472	502	532	562	592	622	652	682	712	742	772	802	832	862
413	443	473	503	533	563	593	623	653	683	713	743	773	803	833	863
414	444	474	504	534	564	594	624	654	684	714	744	774	804	834	864
415	445	475	505	535	565	595	625	655	685	715	745	775	805	835	865
416	446	476	506	536	566	596	626	656	686	716	746	776	806	836	866
417	447	477	507	537	567	597	627	657	687	717	747	777	807	837	867
418	448	478	508	538	568	598	628	658	688	718	748	778	808	838	868
419	449	479	509	539	569	599	629	659	689	719	749	779	809	839	869
420	450	480	510	540	570	600	630	660	690	720	750	780	810	840	870
421	451	481	511	541	571	601	631	661	691	721	751	781	811	841	871
422	452	482	512	542	572	602	632	662	692	722	752	782	812	842	872
423	453	483	513	543	573	603	633	663	693	723	753	783	813	843	873
424	454	484	514	544	574	604	634	664	694	724	754	784	814	844	874
425	455	485	515	545	575	605	635	665	695	725	755	785	815	845	875
426	456	486	516	546	576	606	636	666	696	726	756	786	816	846	876
427	457	487	517	547	577	607	637	667	697	727	757	787	817	847	877
428	458	488	518	548	578	608	638	668	698	728	758	788	818	848	878
429	459	489	519	549	579	609	639	669	699	729	759	789	819	849	879
430	460	490	520	550	580	610	640	670	700	730	760	790	820	850	880

SEND COPIES OF FOLLOWING ARTICLES IN THIS ISSUE

Page No. Title of Article

....

....

....

....

CARD INVALID WITHOUT COMPANY NAME — TYPE OR PRINT

NAME _____

TITLE _____

COMPANY _____

PRODUCT MANUFACTURED _____

ADDRESS _____

CITY _____ ZONE____

STATE _____

Do not use this card after Feb. 26, 1960

MACHINE DESIGN
NOV. 26, 1959

Circle item number for information on products advertised or described or copies of literature.

401	431	461	491	521	551	581	611	641	671	701	731	761	791	821	851
402	432	462	492	522	552	582	612	642	672	702	732	762	792	822	852
403	433	463	493	523	553	583	613	643	673	703	733	763	793	823	853
404	434	464	494	524	554	584	614	644	674	704	734	764	794	824	854
405	435	465	495	525	555	585	615	645	675	705	735	765	795	825	855
406	436	466	496	526	556	586	616	646	676	706	736	766	796	826	856
407	437	467	497	527	557	587	617	647	677	707	737	767	797	827	857
408	438	468	498	528	558	588	618	648	678	708	738	768	798	828	858
409	439	469	499	529	559	589	619	649	679	709	739	769	799	829	859
410	440	470	500	530	560	590	620	650	680	710	740	770	800	830	860
411	441	471	501	531	561	591	621	651	681	711	741	771	801	831	861
412	442	472	502	532	562	592	622	652	682	712	742	772	802	832	862
413	443	473	503	533	563	593	623	653	683	713	743	773	803	833	863
414	444	474	504	534	564	594	624	654	684	714	744	774	804	834	864
415	445	475	505	535	565	595	625	655	685	715	745	775	805	835	865
416	446	476	506	536	566	596	626	656	686	716	746	776	806	836	866
417	447	477	507	537	567	597	627	657	687	717	747	777	807	837	867
418	448	478	508	538	568	598	628	658	688	718	748	778	808	838	868
419	449	479	509	539	569	599	629	659	689	719	749	779	809	839	869
420	450	480	510	540	570	600	630	660	690	720	750	780	810	840	870
421	451	481	511	541	571	601	631	661	691	721	751	781	811	841	871
422	452	482	512	542	572	602	632	662	692	722	752	782	812	842	872
423	453	483	513	543	573	603	633	663	693	723	753	783	813	843	873
424	454	484	514	544	574	604	634	664	694	724	754	784	814	844	874
425	455	485	515	545	575	605	635	665	695	725	755	785	815	845	875
426	456	486	516	546	576	606	636	666	696	726	756	786	816	846	876
427	457	487	517	547	577	607	637	667	697	727	757	787	817	847	877
428	458	488	518	548	578	608	638	668	698	728	758	788	818	848	878
429	459	489	519	549	579	609	639	669	699	729	759	789	819	849	879
430	460	490	520	550	580	610	640	670	700	730	760	790	820	850	880

SEND COPIES OF FOLLOWING ARTICLES IN THIS ISSUE

Page No. Title of Article

....

....

....

....

CARD INVALID WITHOUT COMPANY NAME — TYPE OR PRINT

NAME _____

TITLE _____

COMPANY _____

PRODUCT MANUFACTURED _____

ADDRESS _____

CITY _____ ZONE____

STATE _____

Do not use this card after Feb. 26, 1960

FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

BUSINESS REPLY MAIL
No Postage Stamp Necessary if Mailed in the United States

—POSTAGE WILL BE PAID BY—

MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

Reader's Service Dept.

FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

BUSINESS REPLY MAIL
No Postage Stamp Necessary if Mailed in the United States

—POSTAGE WILL BE PAID BY—

MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

Reader's Service Dept.

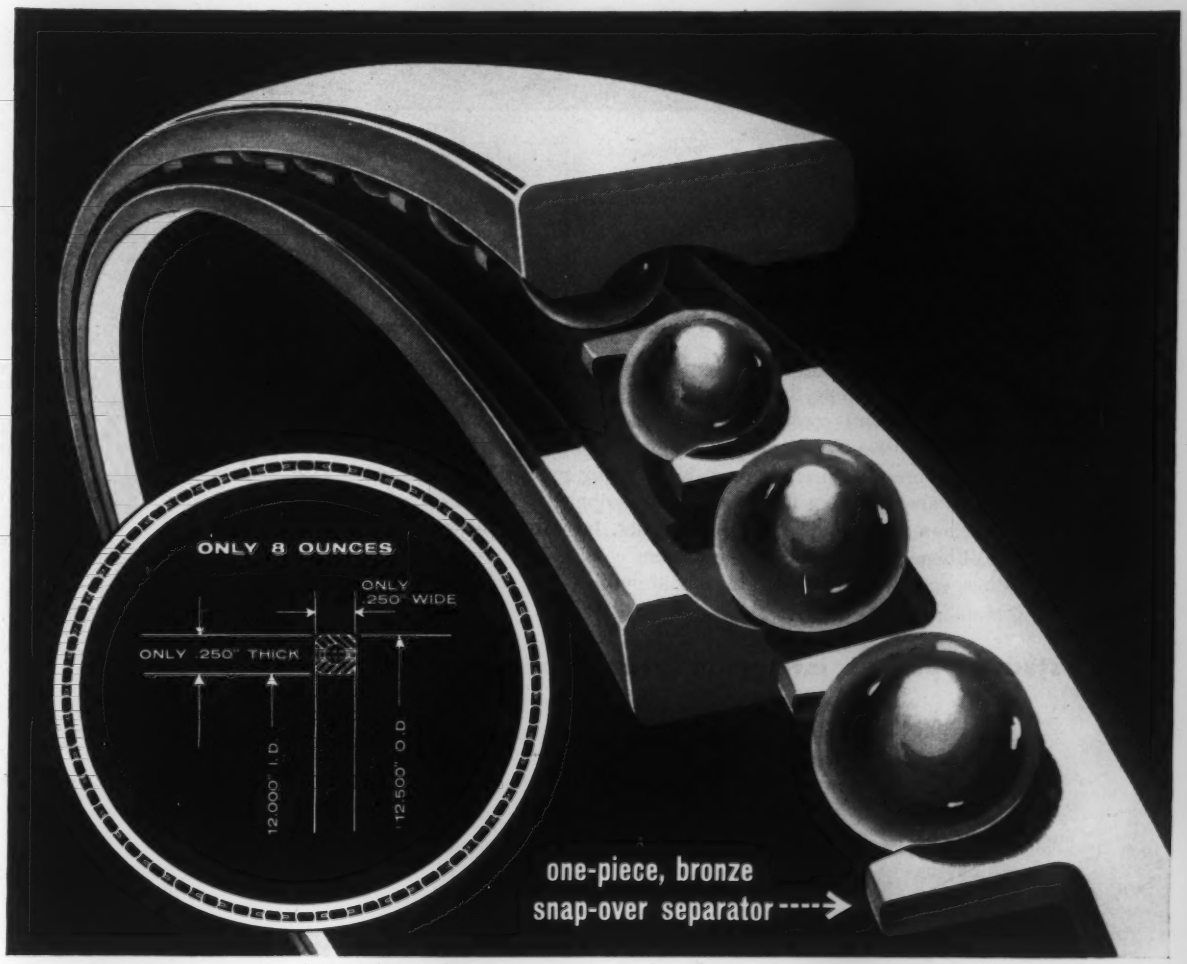
FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

BUSINESS REPLY MAIL
No Postage Stamp Necessary if Mailed in the United States

—POSTAGE WILL BE PAID BY—

MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

Reader's Service Dept.



News from KAYDON!

Reali-Slim bearings "off the shelf" ...prices slashed up to 76%

90 sizes — 4" to 12" bore — 1/4" to 1" width and cross-section

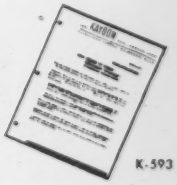
Drastic price reductions — on Kaydon new type "CP" Reali-Slim bearings! Volume production and new bronze snap-over separator permit price reductions from 33 to 76%, depending on size.

Save on bearing cross-section and weight — Reali-Slim is the world's thinnest radial ball bearing. Many sizes of type "CP" are less than 15% of the weight, 34% of the width and cross-section of comparable, extra-light bearings.

Type "CP" with new one-piece, bronze snap-over separator — Major applications include machine tools; farm, textile and paper machinery; printing presses; pumps and gear boxes; missiles, aircraft and radar; gun turrets and dozens of related installations.

Kaydon bearing engineers are prepared to give you valuable help with technical thin-section bearing applications.

New "CP" Reali-Slim bearing bulletin includes prices — gives you full details on these 90 sizes of Reali-Slim bearings with Conrad deep-groove, ball-radial construction. Write for your free copy today.



K-593

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

All types of ball and roller bearings — 4" inside diameter to 178" outside diameter . . .
Taper Roller • Roller Thrust • Roller Radial • Needle Roller • Ball Radial • Ball Thrust Bearings • 4-Point Contact Ball Bearings

NEWS TRENDS

sprayed-on-foam protection proves cheap, dependable

Rigid foam can now be sprayed on a vertical surface without sags or runs. Spraying saves time, labor, and material costs (up to 75 per cent by actual test). Equipment costs are also lower than for older methods requiring expensive positive displacement pumps. Made possible by two developments—a polyether-based urethane capable of being sprayed (by Wyandotte Chemicals Corp.) and spraying techniques and equipment (by DeVilbiss Co.)—the new foam has excellent protective properties. Important advances are predicted by DeVilbiss in insulation and corrosion control of storage tanks, pipelines, and other equipment exposed to the atmosphere or corrosive chemicals.

student pushed into engineering may fall on face

Too many students enter engineering because they get poor guidance from high school counselors or over-zealous parents, says Prof. B. L. Rideout, head of Cornell University's Division of Unclassified Students. The division is an experiment in education—a school for floundering students that rescues about 70 per cent of the undergraduates who are in danger of flunking out. Of the 91 in the unclassified division, 67 have given up engineering. Instead of having to leave the University, however, they will spend one or two semesters in a reorientation program.

picture phone patented

You may soon see the person talking at the other end of the telephone; Bell Telephone Laboratories has patented a TV-telephone combination. Equipment includes a small camera—which can be turned off if you don't wish to be seen—and a small picture tube at each telephone. The camera sends one picture per second over a standard telephone line. At the receiving station, picture diameter is about 1 in. Pictures have been transmitted across the U. S., but quality isn't good compared to broadcast TV. Better transmission lines and higher picture-sending rates will probably both be needed. Bell engineers want to improve the system considerably before it is offered to the public.

plastic awaits nuclear chariot

Thermoplastic resin containing more hydrogen than any other plastic is ready for use in nuclear-powered aircraft, ships, trains, rockets, and space vehicles. The hydrogen content of Marlex rigid polyethylene gives the materials a high degree of neutron-slowing ability, or attenuation, and makes it suitable for shielding or structural members. As a shield against neutron radiation damage, it is superior to water or concrete. Where weight, design, and volume of a shield are important, Marlex offers the best neutron attenuating capability, according to its maker, Phillips Chemical Co., Bartlesville, Okla. Marlex also boasts high density, strength, and durability; it resists chemicals, acids and degrading environments; and it withstands temperatures from −180 to 250 F. For gamma-ray shielding, which requires higher mass, lead can be added.

needed: electronic back-seat drivers

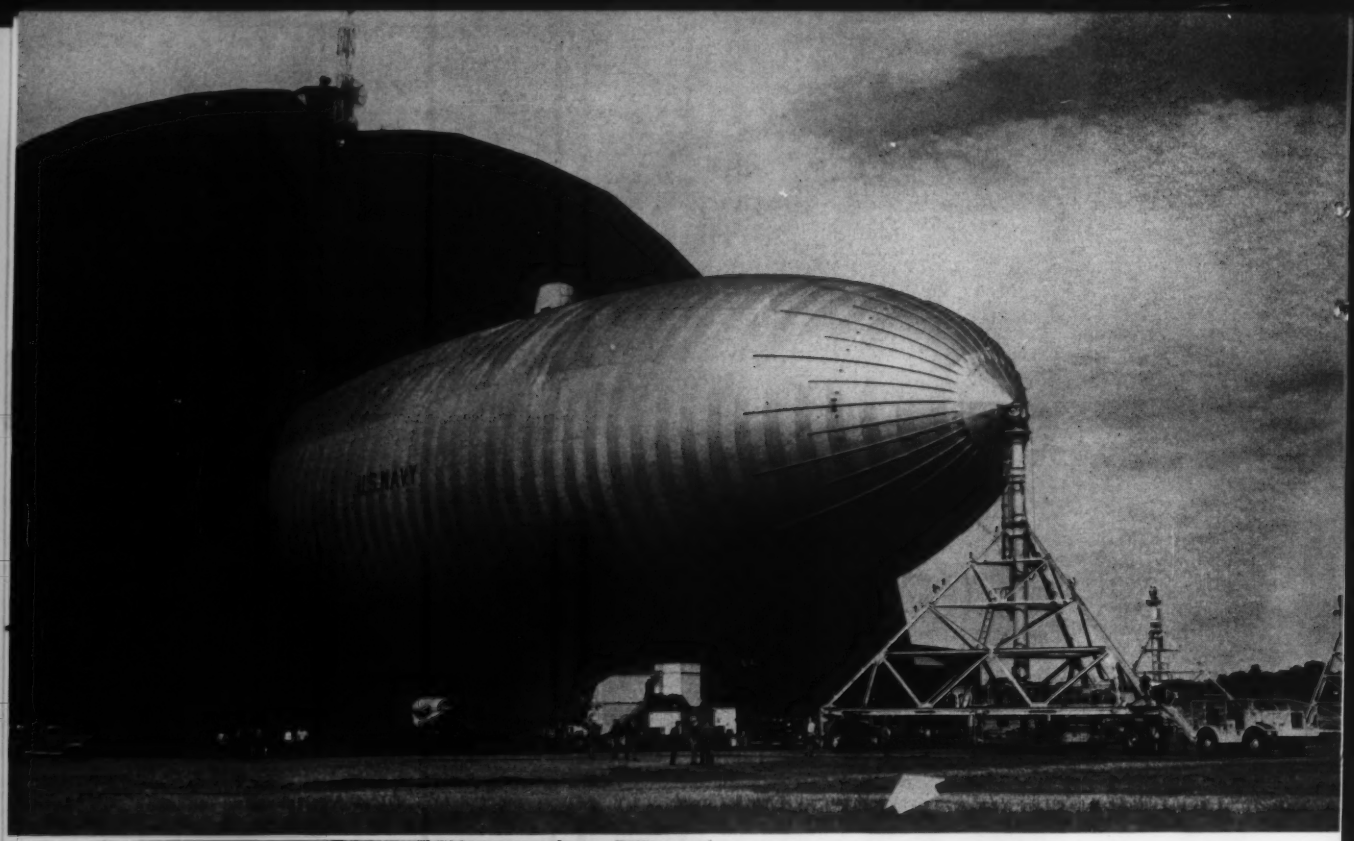
Electronic controls are back in the news as a means of stopping highway slaughter. According to a progress report by Dr. James L. Malfetti, head of Columbia University's Safety Research Institute, inherent human limitations make driver education programs ineffective. Shock-absorbing interiors, doors that don't fly open, seat belts, and other such devices are good stop-gap answers. But in the long run, we need instruments that measure driver responses—variables such as pressure on the wheel, heartbeat rate, breathing rate, amount of head movement, etc. The instruments would trigger automatic systems to warn the driver or, preferably, take over control when responses are not what they should be. Present-day electronics could do the job and, though the cost would be high, it would save many lives.

mower offers choice of cutting grass or fishing

Transition from work to play is mechanical with a new packaged lawn mower and outboard motor. Designed by American Chain & Cable Co. Inc., Bridgeport, Conn., the package consists of a 2½-hp, 4-cycle engine with matching rotary lawn mower and outboard motor assemblies. For boat use the motor is connected directly to the standard propeller assembly. Constant speed is maintained by a unique mechanical governor that allows only 300-rpm decrease in shaft speed before opening the throttle for power surge. Propeller is driven at 2400 rpm through pinion and bevel gears. Conversion from outboard to mower is done in a matter of minutes with simple hand tools. The motor is equipped with an impulse-type starter.

thermoelectricity moves farther out of the lab

The "near future" should bring the public a selection of practical thermoelectric devices, according to W. E. Mahaffay, vice president of research and engineering, Whirlpool Corp. At a recent Whirlpool-armed services-government symposium, the company described a compact water purification apparatus which uses the dual-effect thermoelements simultaneously for evaporating and condensing, thus eliminating the large quantities of cooling water usually required. Also described was a thermoelectric short-order cook for long-range aircraft: A cabinet keeps precooked meals frozen, then current flow through the thermoelements is reversed to heat individual compartments as meals are needed. Whirlpool reports that efficiency of thermoelectric materials has been improved seven-fold since 1950. Still needed: Lower-cost materials, fabrication methods, and rectifiers.



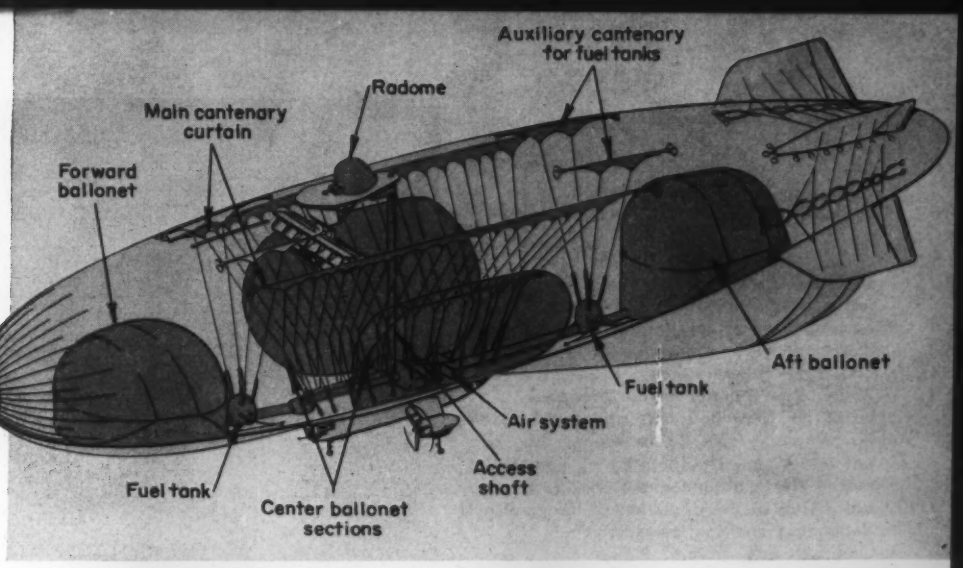
World's biggest airship, Navy's ZPG-3W, was developed by Goodyear Aircraft Corp., Akron, for radar early warning duties. Envelope of the 400-ft long, 85-ft diam craft has no internal frame work, is maintained by controlling pressures of three air pockets (ballonets) inside the hull. Power plants are two Wright 1820-88 engines mounted on outriggers extending from both sides of the car. Airship carries a normal complement of 21, can stay "on station" for days, and be reprovisioned from ships at sea.

Fabric air lines inside the envelope carry all incoming air to a plenum chamber for distribution through damper valves to ballonets. Envelope interior is shown being seamstitched and assembled in Goodyear's Arizona plant. Bags at edges, marking center ballonet sections, contain lead shot and are used for holding envelope in position during fabrication.

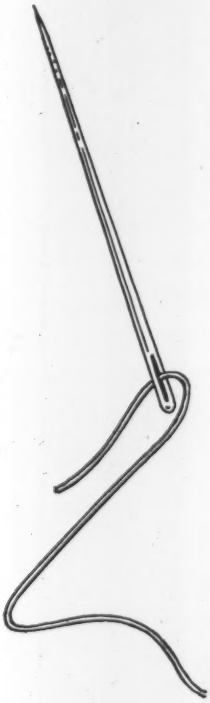
CONTROLLED BREATHING, light materials and a good seamstress are success secrets of the Navy's radar blimps. Stationed far offshore for airborne early warning duties, the world's biggest nonrigid airships house the largest radar antennae ever carried aloft.

Hull of a Navy ZPG-3W, developed by Goodyear Aircraft Corp., Akron, consists of about 8000 sq yd of two-ply neoprene-coated Dacron. This new 0.025-in. thick envelope weighs 4000 lb less than standard cotton-base material.

Improved strength-to-weight ratio of Dacron and other modern fabrics used on the big ship (two-ply neoprene-coated nylon, for example, makes up the fairing and ballonets) permit it to carry 18,000 lb of fuel. Ten years ago, 11,000



Cables and ballonets help the radar blimp keep its figure. The car is suspended by internal cables from the catenary curtains attached to the top of the envelope. Fuel tanks are suspended from auxiliary curtains. The radome, "floating" on top of the envelope, is accessible from the car through the access shaft. Center (two sections), forward, and aft ballonets regulate helium pressure. Air pumped in or bled out of the ballonets compensates for changes in ambient pressure as the ship changes altitude.



How do you shuttle 1.5-million cubic feet of helium back and forth to trim an airship? New Navy radar blimps do it with giant "lungs" that breathe air through a tunnel-size windpipe. Here's an inside look at . . .

Seam-Stitched Pneumatics

lb would have been the maximum fuel load that could have been carried by a ship of the same size. But in those days three-ply rubber-coated materials were all that were available.

The Dacron hull starts out as 2160 longitudinal gores—each resembling a section of banana peel. During assembly, all gores are lap-seamed by special machines with much larger throats than ordinary sewing machines. For the last closure, one arm of the machine is put through a 33-in. hole, later used for mounting a helium valve, to complete the assembly.

Low-Pressure System

Supporting the blimp is a pressure differential between envelope and ambient normally maintained at 0.09 psig. Three ballonets — valved pressure pockets in the air system—are located fore, aft, and center. They maintain shape of the frameless ship and establish trim. By means of a valving arrangement in the manifold, any ballonet can be inflated with air, thus displacing helium from that section of the hull to another.

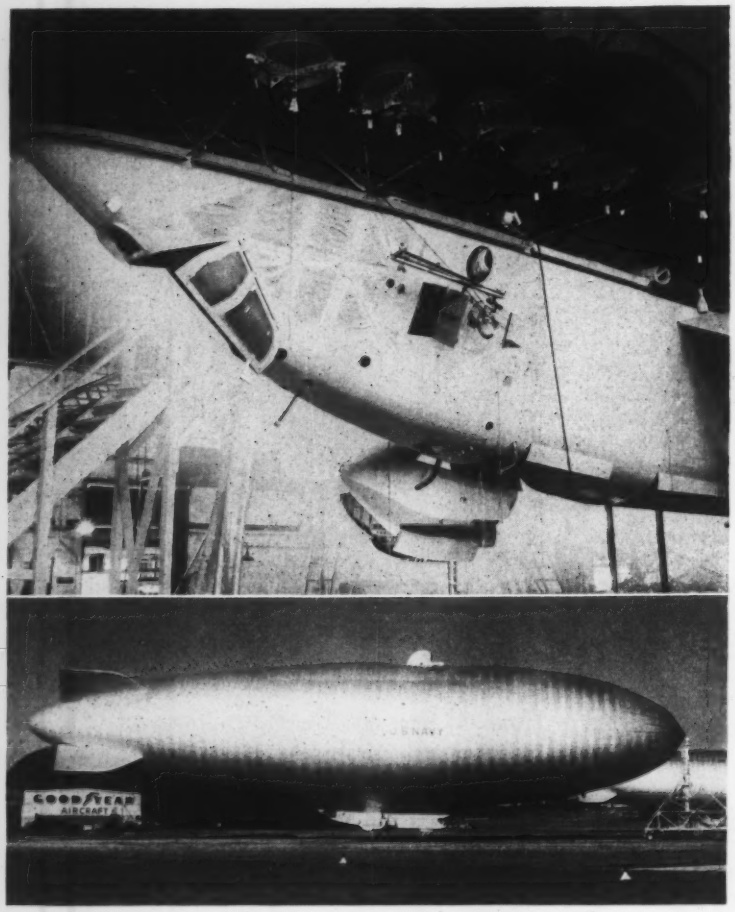
These pressurized pockets are also formed from a neoprenized fabric, but they are inelastic compared to a rubber balloon. Their total capacity is approximately 25 per cent of the displacement of the entire hull.

Air is pumped from the ballonets to compensate for the expansion of the helium as the ship ascends and atmospheric pressure lessens. As the ship descends, the helium contracts, the valves close, and more air is pumped in, expanding the ballonets.

The ballonets are normally filled to only one-third capacity, which leaves considerable room for more air to be pumped in when needed. This minimizes a possible danger for blimp pilots. If ballonets happened to be completely filled before the blimp descended (and helium contracted) ballonet pressure could not be increased. To keep the hull inflated, air would have to be forced in with the contracting gas, thus contaminating the rare and expensive helium.

Large Valves Give Close Control

Twenty-nine giant valves (from 28 to 30-in. diam) maintain pres-



Crew car contains living and working quarters. It is suspended from the top of the envelope by catenary curtains and cables. Starboard view aft shows four air valves and three helium valves. Fourteen of these 28-in. diam poppet valves are used to exhaust air from ballonets and seven to exhaust helium from the envelope. The poppet valves can be operated by electroautomatic, electrical, automatic spring, or manual means at the discretion of the crew and depending on flight conditions.

Nose cone and radar dome are the only reinforced sections of the envelope. Indentation toward top of envelope shows internal line of attachment of catenary curtains to interior. Two main catenary curtains carry weight of the car.

sures within the blimp. Seven of them can exhaust helium from the envelope. The others either admit inlet air or exhaust air from the ballonets.

The valves can be controlled in four ways — electroautomatically, electrically, by automatic springs, or by manual means. (Damper valves that admit inlet air are the one exception; they are not connected to the automatic spring system.) The electroautomatic and electrical systems, identical in many respects, operate valves through rotary actuators integral with the valve structures. In normal flight, the automatic valving system senses pressure and controls ram air or blower pressure through the dampers. The automatic system detects and corrects the gas pressure for an altitude change of 5 ft.

Electric control permits the pilot to juggle system pressures while he observes envelope pressure gages and manipulates flight controls. In this manner, he can anticipate maneuvers by feeding in changes ahead of time. He can thus get more control when he expects radical maneuvers by compensating for a pressure change before it happens.

The automatic spring system functions as a pressure relief control which operates under emergency conditions. The engineering problem was to design a 28-in. valve to operate on a pressure differential of less than 0.5 in. of water. A spring-cam arrangement is set for a given pressure by a screw adjustment.

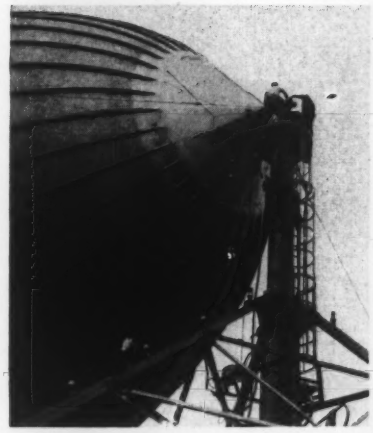
Under flight conditions involving loss of power, ascension of the airship could cause overpressure which might burst the envelope. In this case, the automatic spring arrangement exhausts air first from the center ballonet sections without disturbing the trim condition, next from fore and aft ballonets almost equally, and finally, if needed, helium from the hull until operating pressure is reached.

Manual operation of the valves makes use of straight cable controls, available in the aft fuel and ballast compartment. Controls are available for use if the auxiliary power unit should fail in flight, and for maintaining pressures when the airship is moored.

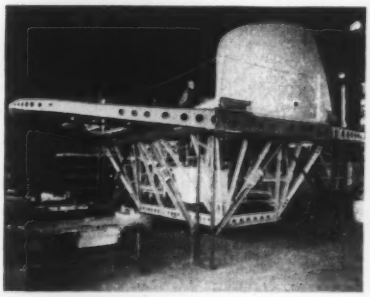
Decks Are Light Too

The story of blimps is one of constant improvements in materials. Honeycomb materials were used for decks as far back as the days of the *Macon* and the *Akron*.

Today's ships make much use of modern, lighter materials throughout the living and working quarters. For example, aluminum honey-



Glass-fiber nose cone is reinforced with tubular, tapered battens. The battens are also made of glass fiber and are installed in lengths of 35 and 80 ft. Although runners still seize hand lines from the descending ship, mooring a blimp no longer requires a ground crew. The hand lines are secured to a winch mounted on a mule, and a mooring mast is attached to the airship's nose-pendant cable.



Topside radar platform "floats" on top of pressurized vessel, due in part to static-lift effect of helium on under surface. Platform is braced to envelope and can be reached by personnel through 85-ft access shaft from car below.

comb sandwich materials are used for floors in all walking areas, 5/8 in. thick sections being butted, spliced with 2-in. strip, and Cherry riveted. For floor areas not used for traffic and for side panels of the cars, a 3/16 in. balsa-core sandwich material faced by aluminum sheets is used. Balsa-core sandwich materials faced with glass fiber are used for side paneling in living quarters by the range and refrigerator, and along lower walls.

CONSIDER THE VITAL HYDRAULIC **C·ZONE**

GOOD DESIGN IDEAS COME TO LIFE WHEN THE CONTROL ZONE IS WATERMAN

A bright design idea! – a ditching machine with hydraulic-powered crowding, controlled independently of the ditching wheel and the spoil conveyor. And it comes to life with Waterman Series 1407 Flow Regulators in the *Control Zone*. Rated for pressures to 3000 p.s.i., and for *controlled* flow rates to 40 g.p.m., Series 1407 Flow Regulators are ideal for the control of hydraulic motors. A 180° turn of the calibrated handle provides a turndown of as much as 80 to 1, with precise, pressure-compensated flow control at any setting. Also available for panel mounting and manifold mounting.

Series 1407 is just one of many Waterman types that make up the most complete line of hydraulic flow regulators – fixed and adjustable. Specify Waterman for flow control and be *right – from the start.*

Waterman Valves and Accessories for Hydraulic Systems

Flow Regulators

Solenoid Valves

Filters

Check Valves

Pilot Checks

Waterman representatives are in all principal cities. Write for Waterman Flow Regulator Catalog No. 1001, and for Waterman Solenoid Valve Catalog No. 2000.

W-5915

Also suppliers of AN and MS qualified flow regulators and fuses.

Waterman Engineering Company, 725 Custer Ave., Evanston, Illinois

WATERMAN ENGINEERING COMPANY

Permanent Optical Memory Scans Photographic Plates

Automatically Exposes, Develops Photos for Switching Circuits

NEW YORK—A permanent memory switches circuits by reading photographic plates in an experimental electronic telephone system. Developed by Bell Telephone Laboratories, the memory calls on stored directory information and other instructions.

Information is contained in thousands of tiny clear spots on the photographic plates. Each plate is divided into seventeen 2-in. square areas. Four plates make up a memory.

The spots are scanned by a cathode ray beam. The beam, focused by a lens system, gives the unit its name: "Flying Spot Store." Beam movement is controlled both electronically and optically and is accurate enough to pick out particular spot locations on each area.

"Store" itself is used to expose the plates. The moving, focused beam strikes a photosensitive area. It is moved over the 2-in. square area and briefly stopped at positions where exposure is wanted. A "slow" photographic emulsion on the plates is not exposed by the passing beam, it requires the lengthened pause.

Photographic memory for Bell Telephone Lab's experimental phone-switching system stores more than 2 million bits of information on photographic plates. It optically reads plates at a speed of 68 bits every 2½ mu sec. Lenses, shutters, and information access plates are visible in the photo. The plate (upper left) contains 500,000 bits of information.

Each of the 17 small plate areas is exposed in turn while others are covered by shutters. An entire plate, containing 550,000 spot positions, can be exposed automatically in less than three minutes.

After exposure, the plates are inserted in automatic processors for developing and fixing. The time required for a complete developing schedule (sometimes involving 15 steps) is less than 30 minutes.

Scientist Cites Menu Problems Of Extended Space Travel

NEW YORK—The cow, with vast experience in moon travel, may contribute to the solution of space voyagers' menu problems, according to a prominent space scientist.

Dr. Norman L. Barr, chief of space environment and life sciences research, Republic Aviation Corp., says that by artificially simulating the unique digestive process of a cow, scientists can test the practicality of converting normally indigestible food-plant fibers into meat substitutes and sugars.

Principal advantage of this approach, if successful, is not only the creation of a new source of food and a variety of essential protein, fat, vitamins and minerals, but the elimination of still another problem —leftover food scraps. Food plants are composed primarily of unused residue in the form of stalks, leaves and roots. Protein is buried within cellulose walls, indigestible to humans. Animals such as cows, through bacterial enzymes, can convert these plant cell walls to sugar, liberating the protein. This digestive process can be duplicated in a space vehicle, according to Dr. Barr.

The scientist also confirms the fact that several research groups are deeply engaged in experiments designed to reclaim human liquid wastes. Work of this nature is being conducted at Republic, for instance, where the waste water is distilled under vacuum at low temperatures (easily done in space) to produce a chemically pure, palatable ingredient.

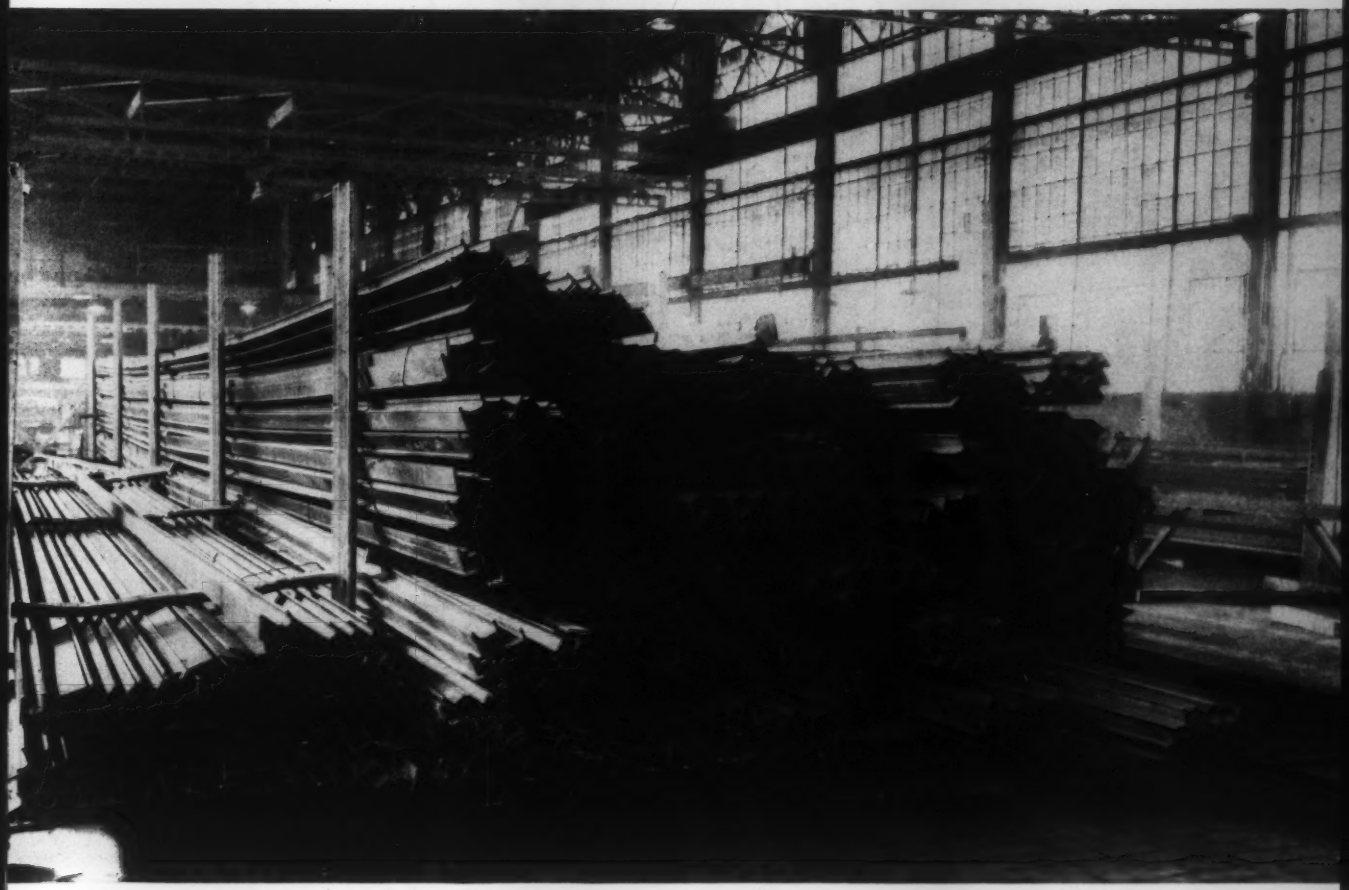
On an extended space voyage it is probable that more water will be reclaimed than is needed for drinking and bathing. The excess, however, can be used in combination with waste carbon dioxide to form oxygen and food for plant life.

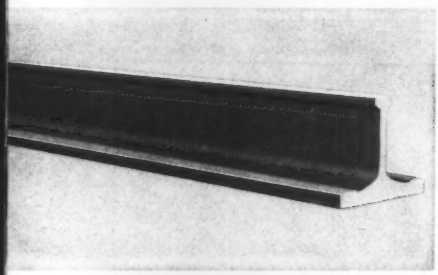
Astronautical Fringe Benefit: A Long Lunch Hour

Time expansion, which accompanies speed, may have some fantastic effects on interstellar food requirements. For example, Dr. Barr explains that a space traveler rocketing toward outer space at speeds just slightly below that of light (186,000 mps) would have his watch—and digestion—slowed down to such a degree that he would require only one dinner for each 6570 dinners eaten by his earthbound friends.

To carry this further, man could make a round trip to one of the planets of Sirius, which is nine light years from the sun, and need nothing more than a box lunch for the trip. Technically, the trip would take 18 earth-calculated years to complete, but the phenomena of time expansion and contraction of space, would make the apparent time lapse less than one day.

STEEL SHAPED TO CUT COSTS AND IMPROVE PRODUCTS





A one-piece rail rolled for the runway of Cleveland Tramrail Systems. This track has flat raised treads designed to minimize peening. No machining is required on this USS Special Section.

Tramrail—non-peening, no machining made from USS Special Sections

This supply of rails for Cleveland Tramrail Systems represents a cost saving running into many thousands of dollars. They are USS Special Sections rolled to exact size and cut to proper length. If the rails had to be machined from bars of high-carbon or alloy steel, the cost would be prohibitive and scrap losses tremendous.

The steel is furnished in a high carbon grade which serves to minimize track wear caused by wheel peening on the track tread. The manufacturer says that in 30 years no other overhead track has been offered that surpasses this one for durability.

It's seldom that better products can be produced at substantially lower costs but that's what happens when you use rolled USS Special Sections. Rolled to the predominating cross section needed, it is a custom-tailored part, designed and rolled so that there is little or no finishing required to meet final specifications.

Why not find out what USS Special Sections can do for you? This is one *sure* way you can help to keep costs down and get faster production at the same time.

Write for our new book, USS Special Sections. United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

USS is a registered trademark

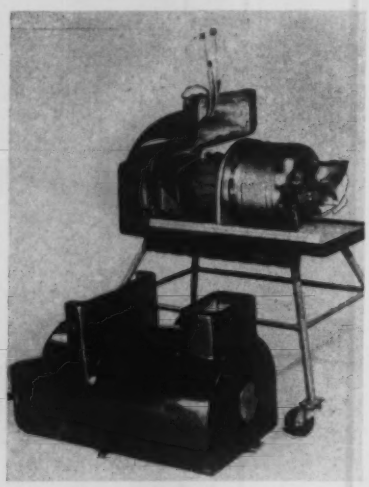
USS

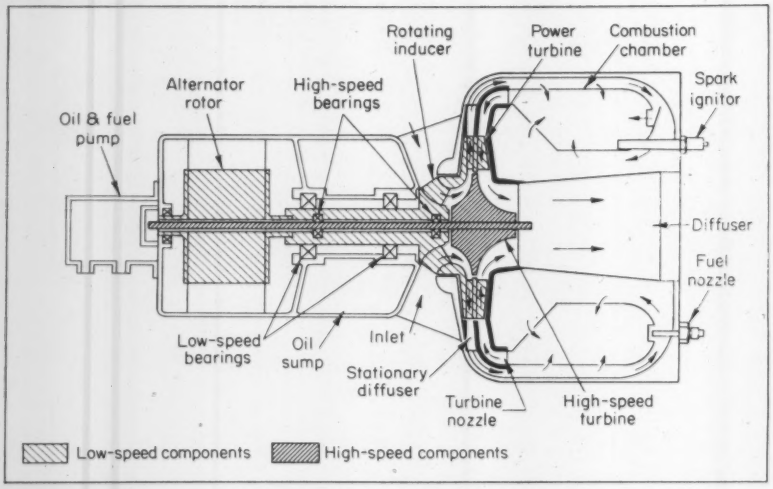
United States Steel Corporation—Pittsburgh
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Export Company

United States Steel

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

Portable Gas Turbine Weighs 30 lb





Electric or pneumatic power, or a combination of both, can be supplied by a compact gas turbine that comes in 5 or 10-hp ratings. Designed by Curtiss-Wright Corp., the miniature power source is only 13½ in. long and 10 in. in diameter. Its high-speed compressor and turbine (centrifugal compressor; radial inflow-axial outflow turbine) are mounted back-to-back, an arrangement that keeps the hot turbine cool by conductive heat transfer to the compressor side of the wheel. The load is driven by a power turbine which rotates at 24,000 rpm. Reduction of mainshaft speed (92,000 rpm) is accomplished by the rotating inducer. Specifications for the 5-hp model: Power output at sea level, 6.3 hp or 4 kw; fuel consumption at rated load, 3.1 lb per hp/hr; turbine inlet temperature, 1200 F.

Simple New Reactor May Supply Cheap Power

Pump is Only Moving Part Of Unit Being Built

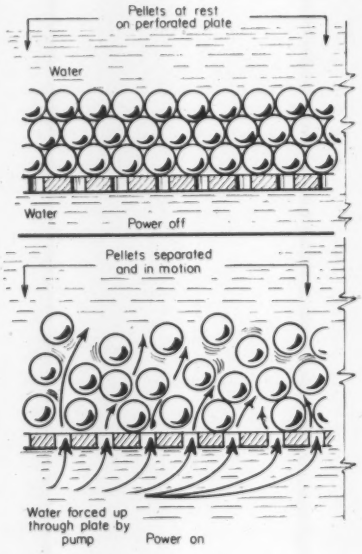
BALTIMORE—Prototype of a new reactor breed promises cheap electricity for peacetime power. Under development by Martin Co., Nuclear Div., it is soon to be tested.

Called "liquid fluidized bed reactor," the highly advanced system uses a moderate-priced fuel—Uranium-238 slightly enriched with U-235—and has only one moving part, a pump. A large upright cylinder contains the fuel (pellets the size of peas) immersed in water. The pellets rest on a perforated false bottom when the reactor is "off." When it is turned "on" a hydraulic pump forces water up through the perforations; the pellets, caught in the water stream, rise and move apart, starting a chain reaction.

In the off position, the pellets will not support a chain reaction. Neutrons are ejected from each pellet, but they are absorbed by the U-238, a process that releases very little energy. In the on position, the water slows the neutrons to *less than* U-238 capture velocity and they get through to the U-235. They still have sufficient energy to split these atoms, and a chain reaction starts. The reaction heats the water, which is taken off as steam at the outlet. A steam-driven turbine supplies the electricity.

Present-day reactors are turned on and off by movement of neutron-absorbing control rods (moderators). They are pushed into the core to take neutrons out of circulation and are pulled out to build up the reaction. The new reactor should eliminate both the rods and the complex equipment needed to actuate the rods, and also fail-safe devices. If the pump fails, it fails safe because the reaction slows down as the gaps between pellets decrease.

The fluidized bed reactor concept is not new, but this work (under an AEC contract) is the first effort to produce a working prototype. Under the contract, the company will also study abrasion effects on various types of pellets and will conduct tests on the reactor.



Advanced reactor "burns" fissionable fuel pellets. The pellets cause a chain reaction only where separated by a liquid moderator. Water pumped upward through the perforated plate nudges the pellets apart, turning the device on. Now being developed by Nuclear Div., Martin Co., the reactor may be capable of producing cheap power for industrial uses.

MEET MRS. PETER PEFF

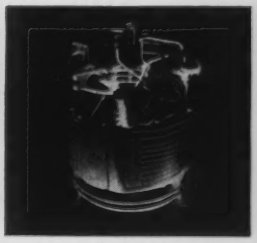
...and her company's new lightweight liquid-oxygen "vacuum bottle" for jet planes

Mrs. Peff, president, Superior Air Products, Newark, N. J., with Supairco's recently developed liquid-oxygen "vacuum bottle."

MANY a tough problem has been solved by Mrs. Peff and her company since 1952, when she assumed the presidency after her husband's death. Specialists in building low-temperature apparatus and complete plants to produce oxygen and other gases, "Supairco" was asked recently to develop a light, compact container to supply oxygen for aircraft crews at high altitudes.

Ingenious design utilizing the broad and varied properties available in copper and its alloys produced the "vacuum bottle" shown above. The inner sphere is of Everdur®, Anaconda copper-silicon alloy, which has the workability and resistance to corrosion needed —and, more important, the strength and toughness to make possible a relatively thin, light shell that can withstand vibration and fatigue stresses aloft—plus shocks from catapult launchings and carrier landings. The outer shell is of Anaconda copper, highly polished to reflect heat. This, plus a vacuum under .001 microns between the spheres, holds liquid oxygen at —297 F.

Starting with over 100 standard copper alloys, Anaconda can provide an almost unlimited number of combinations of useful properties. When new and unusual problems arise, use Anaconda technical specialists to help you select metals for your needs. Address the American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 5941

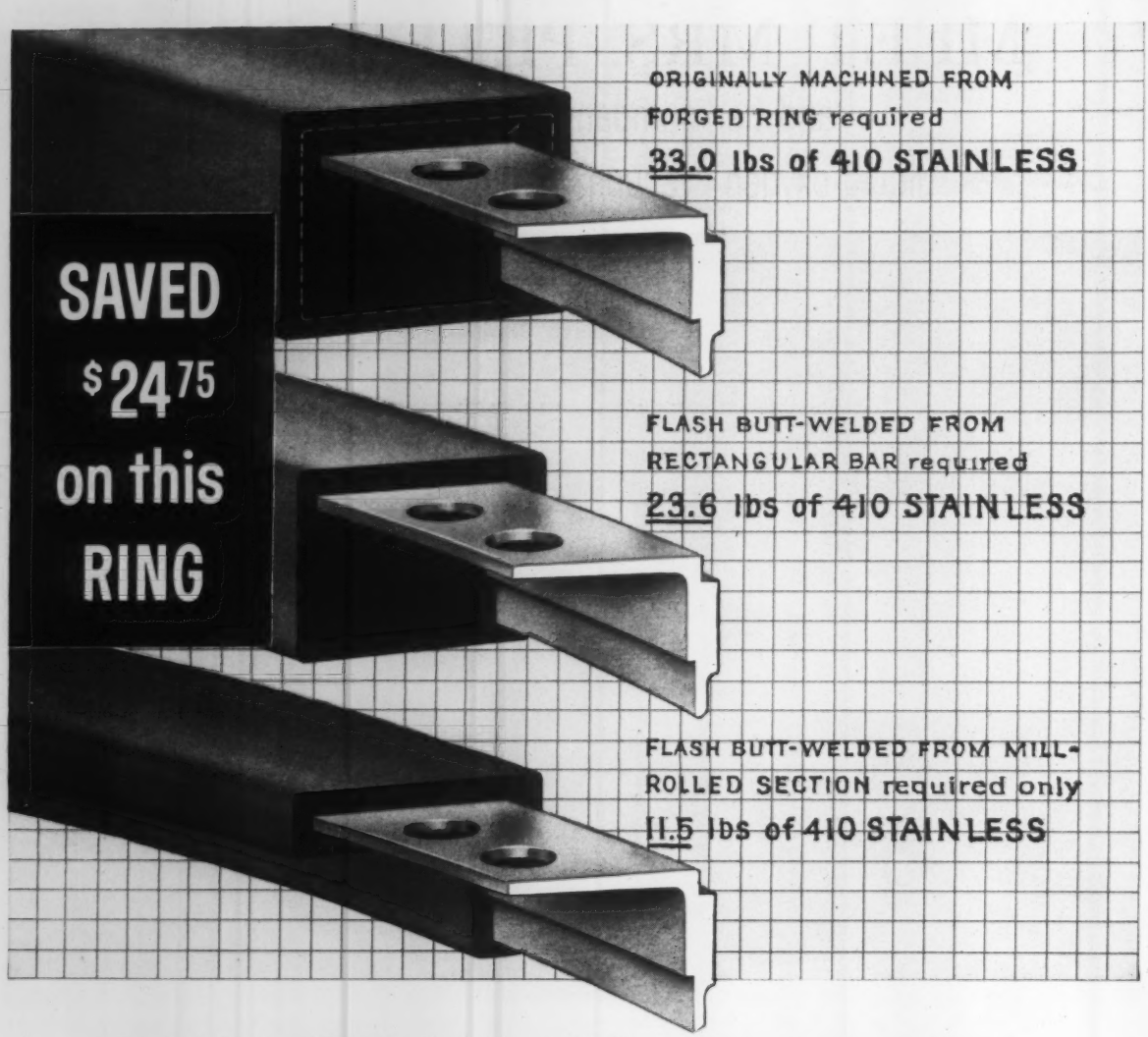


LEFT: Inside the copper shell in main illustration is this slightly smaller liquid-oxygen container made of Everdur, the metal that spins and machines readily, is easy to join by soldering, brazing, welding. **RIGHT:** Completed liquid-oxygen converter, built by Mine Safety Appliances Company, Pittsburgh, Pa., serves 8-man crew. It is one-third the weight of the cylinder it replaces, takes much less space.

ANACONDA®

COPPER • BRASS • BRONZE
NICKEL SILVER MILL PRODUCTS
Made by The American Brass Company

Circle 415 on Page 19



Switch to flash butt-welded compressor ring saves 21.5 lbs. of material—cuts machining time

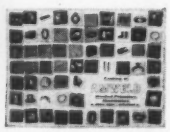
By selecting a special mill-rolled section close to finished dimensions, only 1/3 as much material was required to produce this ring. (Similar material savings could be realized on extruded sections.)

In addition, 45 minutes of expensive machining time were eliminated.

Flash butt-welded rings like this have been used in critical applications such as jet aircraft engines and present day missiles. They offer cost saving advantages in many fields, particularly where stainless or other heat or corrosion-resistant materials are employed.

Amweld's experience in forming, welding and machining circular parts is available to you. Write or call today. Or send blueprints and specifications—we will be glad to study your problem.

LEARN HOW FLASH BUTT-WELDED RINGS CAN REDUCE PRODUCTION COSTS.



THE AMERICAN WELDING & MFG. CO. • 130 DIETZ ROAD • WARREN, OHIO

AMERICAN WELDING

Slick Gear Foldup Cleans Up a Highwing

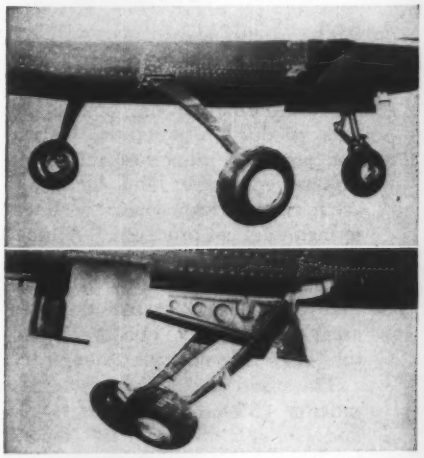
Flight Specs for Model 210

Speed:	
Maximum @ sea level	199 mph
Cruise (75% power @ 7000 ft)	190 mph
Range:	
Maximum recommended (normal lean) 75% power @ 7000 ft	755 mi
55 gal (no reserve, max range mixture)	1100 mi
Service ceiling	20,700 ft
Stall speed: Flaps down	59 mph
Take-off: Over 50-ft obstacle	1135 ft
Landing: Over 50-ft obstacle	1190 ft
Gross weight	2900 lb
Engine (Continental 10-470-E)	260 hp

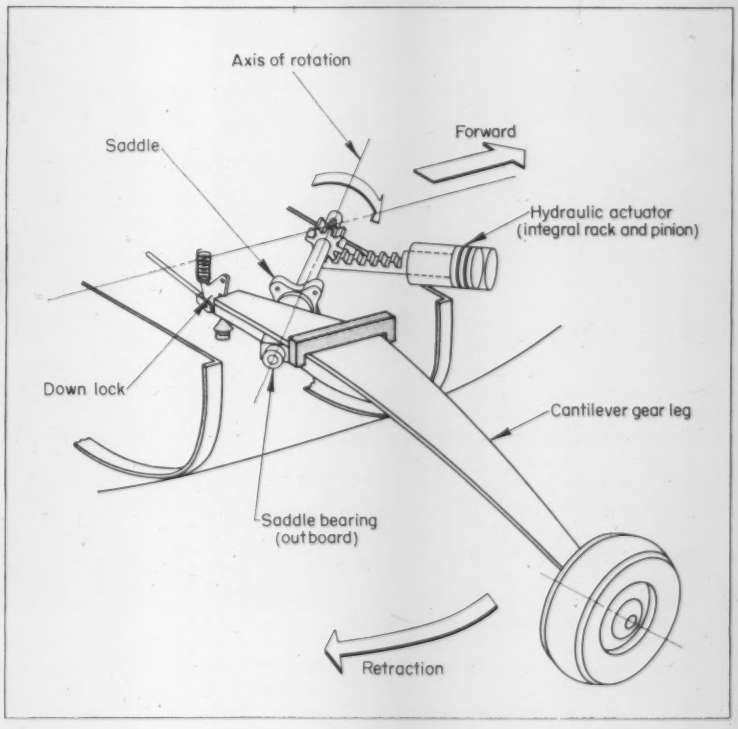
WICHITA, KANS.—Airframe designers at Cessna Aircraft Co. have worked out a unique solution to an old retractable-gear "packaging" problem: Where do you stow retracted gear legs and wheels on a high-wing airplane? Cessna's uncluttered answer for their high-performance Model 210 uses no articulated side links, adds less than 100 lb to the basic gear, and helps boost the 210 to a presentable 199-mph top speed.

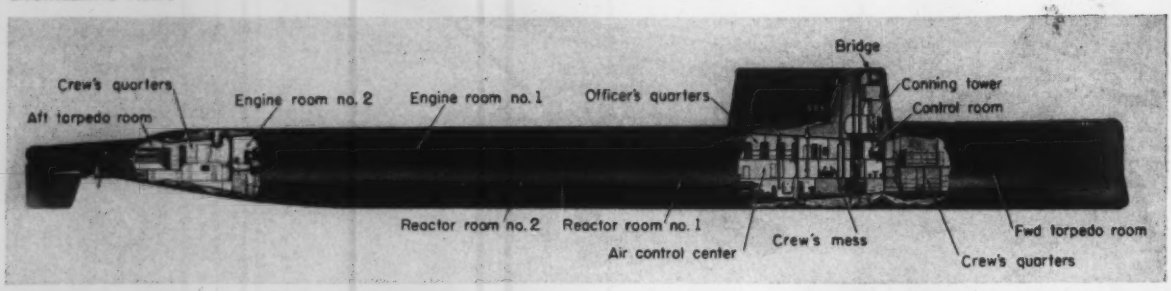
Secret of the design (first on a utility high wing) is the cantilevered, spring-steel gear leg—long an identification feature on Cessna's single-engine line. Main-gear hydraulic cylinders—lying on a horizontal plane and angled to the fuselage centerline—generate rotational motion for the retraction cycle through a rack-and-pinion mechanism integral with each cylinder package (racks are cut on the piston-rod extensions). Rotation of pinions and gear-leg saddles swings the gear aft along the fuselage and into sealed compartments behind the cabin section. The nose gear retracts forward under the engine.

Company officials say the 210 should be an easy "transition" for business pilots who have been flying lower performance aircraft with fixed gears. Ground and air-handling characteristics are claimed to be as good or better than those of smaller, slower, single-engine planes in the Cessna line.



Packaged design for the 210 main-gear actuators incorporates a linear hydraulic cylinder and a built-in rack-and-pinion. Rotation of the gear-leg saddle (about an axis angled to the fuselage centerline) swings the gear aft into sealed compartments. Weight of the ship in the gear-down configuration is supported by outboard structural castings (between bulkheads) and adjustable support points at inboard ends of the spring-steel legs.



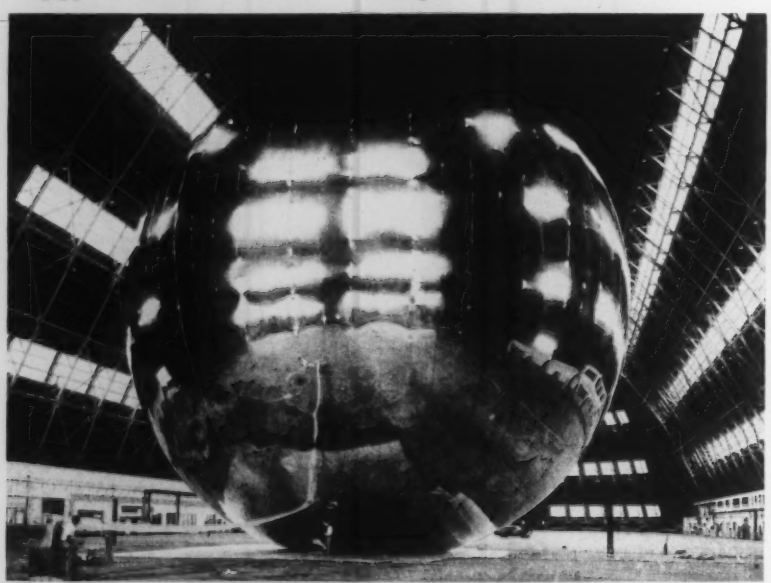


"Submersible Cruiser" Ready for Action

Powered by twin reactors and packed with electronic gear, the world's biggest submarine has joined the U.S. fleet. Triton, commissioned early this month, can cruise 110,000 miles (or two years) without refueling and will be the eyes and the ears of the fleet at sea. A vast array of detection and countermeasures equipment accounts for the triple-deck vessel's tremendous size. She is twice as big as a conventional submarine, 100 ft longer than a destroyer, and displaces as much (5900 tons) as a light cruiser. Her two powerplants drive separate screws; the same design concept used in surface ships. Triton will be the only nuclear sub capable of refueling at sea. Her reactors incorporate a unique unit-cell core which permits

each core to be removed individually through a hatch in the hull. On other nuclear subs, access to the reactor is gained by cutting away part of the hull. Triton was built by Electric Boat Div., General Dynamics Corp.

Saggy Satellite Will Be Target for Trackers



New balloon-like satellite derives no lift from its gas-filled micro-thin plastic bag. The 100-ft diam bag helps observers on earth locate the vehicle in the heavens. It is inflated only after it arrives in space, for it starts the journey folded in a 30-in. diam sphere, right. Once in space the sphere is ejected and inflation is begun by automatic release of four pounds of water (the water immediately vaporizes in the near-vacuum of space). Two uses for the NASA satellite are predicted: Use as a lunar probe, in which case it could be tracked by earth's astronomical equipment, enabling scientists

to pinpoint its location; and use as an earth satellite to reflect radio and radar beams for investigation of forward-scattering techniques.

ASM's New King-Size Memory Will Supply Metallurgical Data

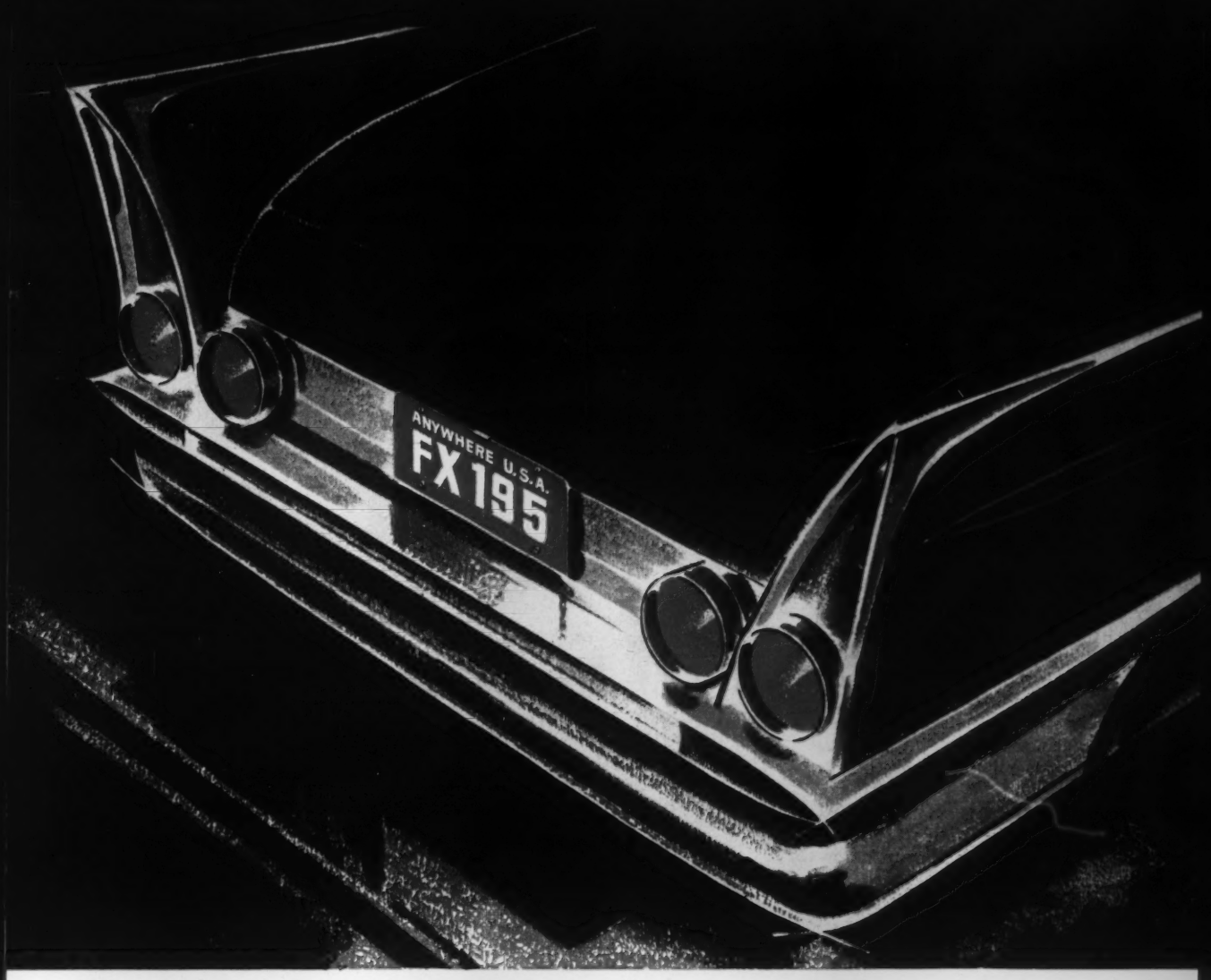
Literature-Searching System Screens 100,000 Titles per Hour

CLEVELAND—Abstracts of as many as 40,000 documents a year may eventually be committed to the memory of a new American Society for Metals searching service for metallurgical literature.

The Metals Documentation Service, to be inaugurated early next year, will cover the world's published information on "metals, all their production processes, fabrication methods, properties and applications, equipment and fuels, and even refractories, where pertinent to metallurgical processes." A broad interpretation of subjects pertinent to the field of metallurgy will eventually lead MDS to include fringe areas and closely related fields—solid-state physics, for example.

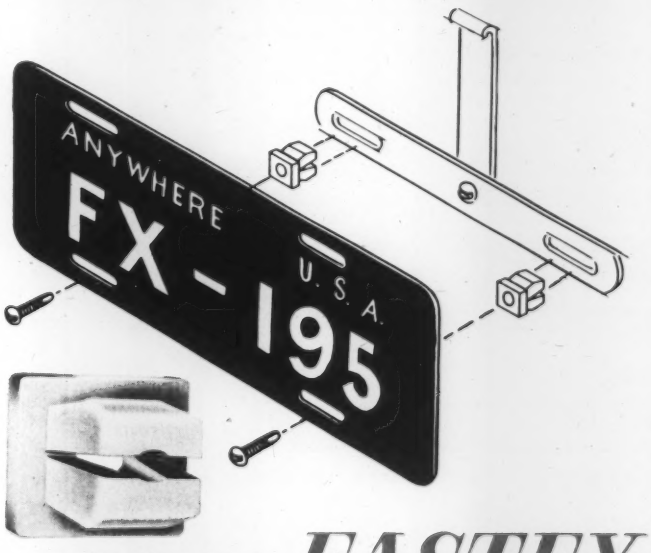
Titles and short abstracts of documents (books, periodicals, U. S. and foreign government reports, monographs — even house organs) will be available to subscribers. Titles will include current literature —from U. S. magazines only a week or two old, and from foreign journals a month after publication.

The lightning-fast librarian employed by ASM/MDS is a General Electric computer-type machine, the GE-250, which was developed especially for this job. Unreeling its



Tough fastening problem... simple answer:

FASTEX® PLASTI-GROMMETS®

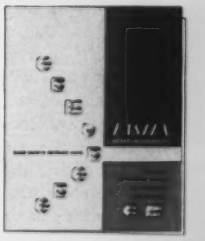


Using Fastex Plasti-Grommets to mount license plates demonstrates their use in blind applications, just one of their unique solutions to fastening problems. They are also ideal for any application requiring rugged fastening strength, electrical or thermal insulation, corrosion-resistance and ease of assembly. They snap into place easily and lock tight when the screw is driven.

Fastex Plasti-Grommets have been specified by leading manufacturers for years. Typical of the many mass-production industries they serve are television, where they are used as electrical insulation fasteners, and in manufacturing refrigerators where they serve as thermal insulation spacers.

SEND FOR NEW CATALOG FEATURING STANDARD PLASTI-GROMMETS!

Fastex Standard Plasti-Grommets can mean big cost-savings! This new catalog contains handy ordering information and idea-suggesting case studies. See where Plasti-Grommets can cut your costs!



Circle 417 on Page 19

FASTEX

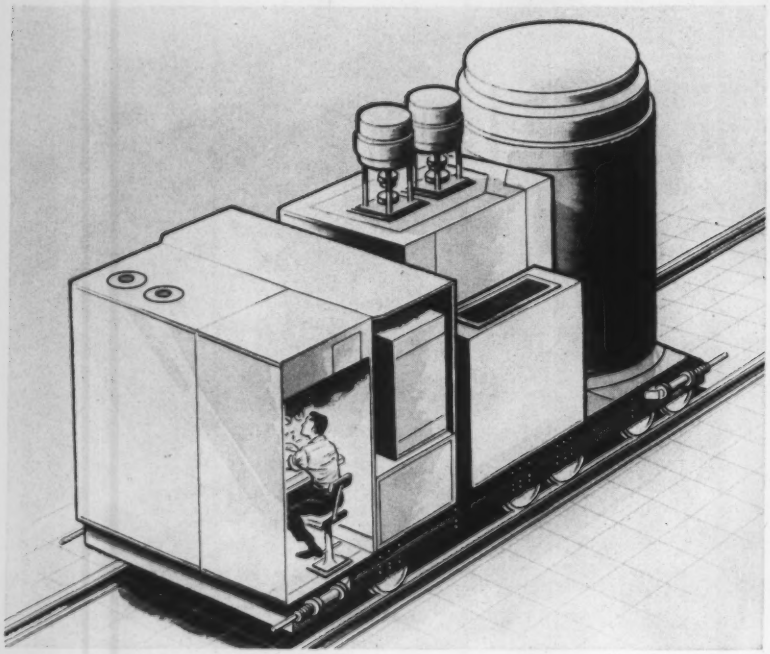
A DIVISION OF ILLINOIS TOOL WORKS
195 Algonquin Road, Des Plaines, Illinois
In Canada: SHAKEPROOF/FASTEX
Division of Canada Illinois Tools Ltd., Don Mills, Ontario

itw

coded magnetic tapes, the machine will be able to search 100,000 indexed documents per hour and print out titles and sources of those pertinent to the subscriber's need. As many as ten inquiries can be fed into the machine at once, and tapes are searched at the rate of 15,000 characters per second.

Four types of service are available to subscribers of ASM/MDS:

- Current awareness searches provide prompt, current information on a specific problem in the form of pertinent abstracts sent every two weeks. Photocopy service is available.
- Generic searches, also sent every two weeks, are provided on subjects of wide interest. A larger number of subscribers reduces cost of this service.
- Retrospective (bibliographic) searches involve bibliographies of previous literature on any subject or subjects, prepared on demand. The machine library, as well as conventional library indexes, is utilized.
- Encoded tapes of the year's literature are available to subscribers who want their own searching machine, by special arrangement. This setup permits processing of individual or confidential information not provided by ASM.



Atomic Age Wheelbarrow

Rail-mounted vehicle for handling nuclear fuel is a Jules Verne juggernaut complete with shielding. Major sections of the 180-ton fueler include: A vertical, barrel-like cask for carrying "hot" fuel; a heat transfer system for getting rid of decay heat; and a control cab to house the operator. Designed and being built by Baldwin-Lima-Hamilton Corp., Philadelphia, the transfer-cask car will find work at the Enrico Fermi Power Plant now under construction. Positioned over an exit pipe from the reactor shell, it will lower fresh fuel cartridges (via a built-in hoist and gripper mechanism) into the reactor and will receive spent cartridges in return. The hoist lifts the spent cartridges (in sodium-filled soaking pots) into the cask where they are temporarily stored.

Project ORCON: A Featherweight Guidance System

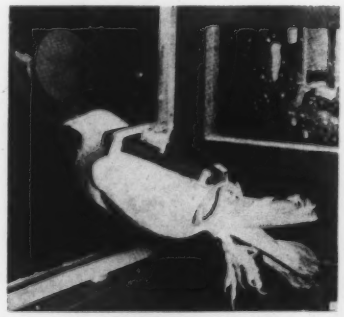
ORCON (organic control) is the code name of a study the Navy has kept under secret wraps for the past six years. ORCON's goal: To use pigeons as a means of missile guidance. The birds were not expected to use their homing instincts (linkage was evidently a problem here), but were merely trained to peck in the right place at the right time.

Here's how ORCON would operate: The missile would be equipped with a lens in its nose which would focus the target image on a gridded-glass screen as the missile homed-in. A pigeon, trained to peck at the appearance of any distinguished object, would be positioned behind the screen, with an electrical contact cemented to his peak. If the missile were off course in its flight, the target-image would be displaced from center on the screen. The pecking of the pigeon at the image would make a contact (pick-off) with the gridded glass, indicating how far the missile was off course. The error signal would be automatically translated as a correction to the steering mechanism, causing the missile to home-in on the target.

Two factors largely governed ORCON's performance: The bird's pecking frequency and pecking accuracy. During primary tests, it was found that peck frequency was approximately 4 per second; peck accuracy ranged between 80 and 90 per cent.

Translated into guidance terminology, the bandpass frequency of a smart pigeon was 7 radians per second. This was judged adequate to operate a missile servo mechanism, and the chances of scoring a target hit or effective near-miss were excellent.

This remarkable performance, however, was achieved under ideal conditions. Later tests showed that clouds, shadows, and other natural phenomena would confuse the birds. And the system wouldn't work at night, of course. So ORCON was finally abandoned for more sophisticated, but less personable, devices.



Non-gimbaled pigeon with a wired beak—key to Navy's organic guidance system—offered one big asset: It couldn't be jammed.

Circle 418 on Page 19→

THE "CROWNING" TOUCH

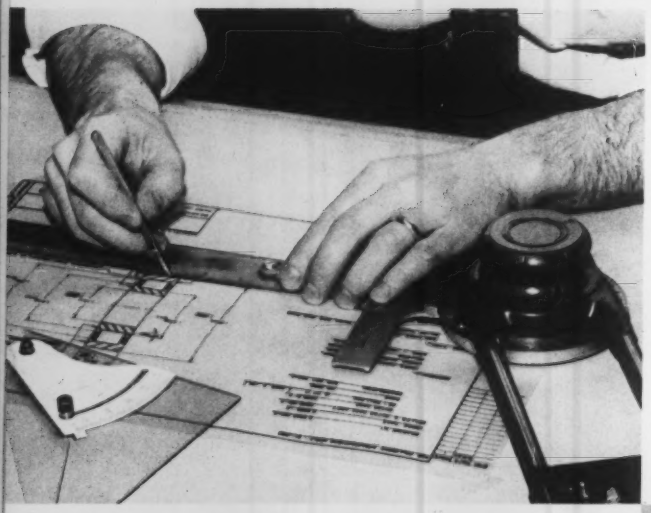
makes things run smoother on

HYATT ROLLER BEARINGS

IN ROLLER BEARINGS HYATT IS THE WORD FOR GM GENERAL MOTORS RELIABILITY

CROWNED ROLLERS and HYATT

assure 3 performance advantages

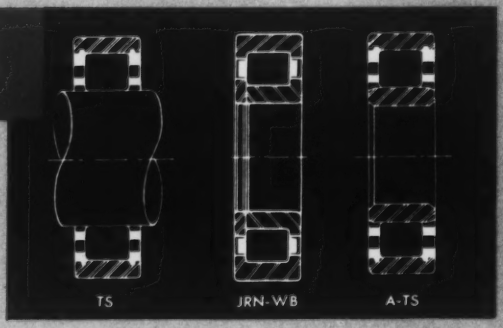


Grinding a gentle crown on cylindrical rollers, a practice pioneered by Hyatt, provides definite operating advantages in a finished bearing.

When a cylindrical roller is rolled across a flat plate there is a tendency for the imposed loads to be concentrated toward the roller ends. When rollers are assembled into bearings this condition is exaggerated, somewhat, particularly if there is a condition of misalignment.

All rollers in Hyatt Metric Series Radial Bearings are crowned. This crowning reduces the tendency toward end loading and the effective load is spread more evenly across the full length of the roller even under misalignment.

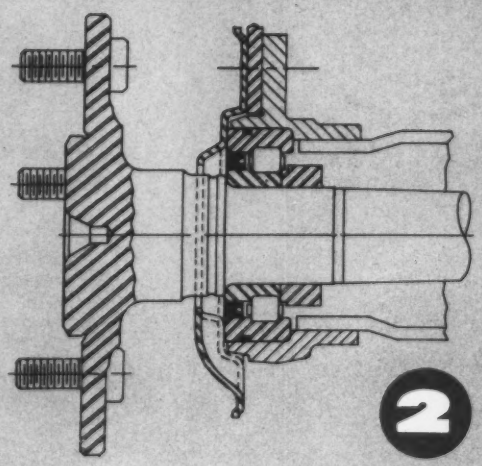
3 KEY BENEFITS WITH HYATTS



● **ALL HYATT HY-ROLL METRIC SERIES BEARINGS** have rollers with ample crowning in addition to generous corner radii or blended chamfers. This crowning extends a sufficient distance in from the ends to allow the area of contact to "fade out" evenly under normal loads, and to minimize excessively high unit loads caused by possible misalignment. This feature, another HYATT "first", assures a quieter, smoother running and longer lasting bearing under all operating conditions.

● **THE LOW LENGTH-DIAMETER RATIO OF HYATT ROLLERS** eliminates virtually all tendency to skew, which can be troublesome in bearings having a different roller length-diameter ratio. By most closely approaching true rolling action, HYATT Hy-Rolls assure less friction, less wear on rollers and races, and increased service life.

● **GREATER LUBRICATION CAPACITY IS ANOTHER ADVANTAGE** of expertly-engineered HYATT Hy-Roll design. HYATT Hy-Rolls are easy to keep properly lubricated for efficient, economical performance and trouble-free maintenance.



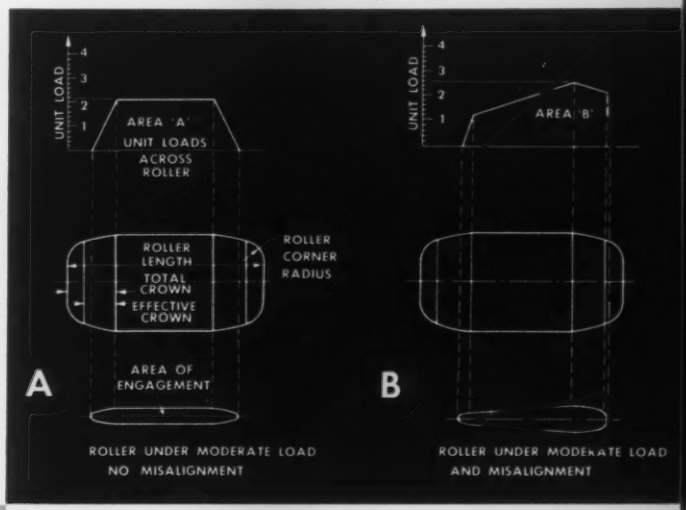
NO BEARINGS CARRY RADIAL LOADS LIKE *CYLINDRICAL*

LENGTH TO DIAMETER RATIO

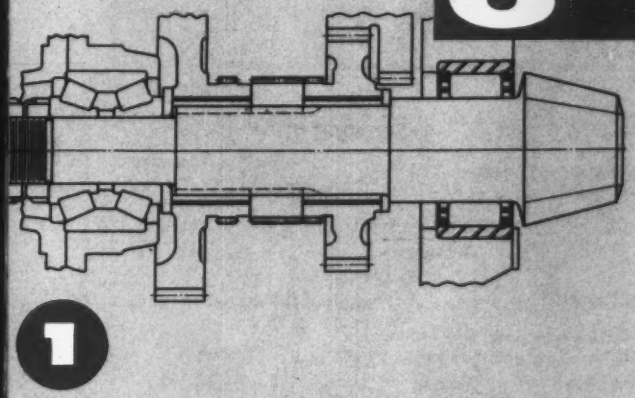
when you design around HYATT metric series bearings

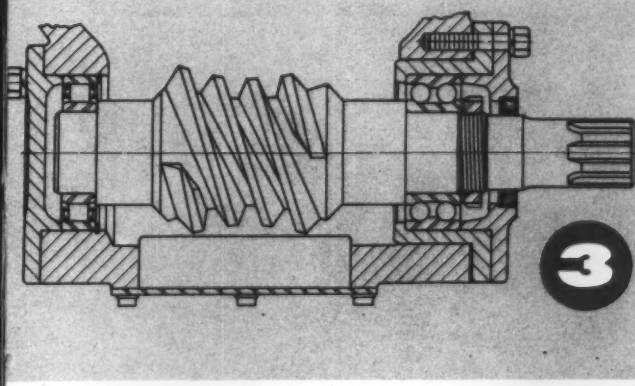
Balanced design is the key to improved field performance of bearings. The relationship between inner races, outer races, cages and rollers must be carefully evaluated because a bearing, like a chain, is only as good as its weakest component.

There is a relationship between the load carrying capacity of a cylindrical bearing and the area of contact between the rolling elements. Over long years of test and evaluation Hyatt has established a roller length to diameter ratio which provides maximum capacity with optimum roller retainment and guidance. The proportions used in Hyatt Bearings have stood the test of time and field usage to become the standard for cylindrical roller bearings.



3 TYPICAL APPLICATION EXAMPLES





1 OVERHUNG PINION IN LIFT TRUCK TRANSMISSION A HYATT Hy-Roll Type TS bearing provides the load-carrying capacity so necessary in this heavily loaded position. By eliminating the separable inner race, it was also possible to use a larger, more rigid pinion shaft without disturbing the boundry dimensions of the bearing. Roller crowning improves performance and compensates for inability to bring shaft finishes up to bearing inner race standards.

2 TWO-DIRECTION AXIAL SHAFT LOCATION Misalignment present in an application like this automotive rear axle requires the compensating effect of a crowned roller. HYATT Hy-Roll Type JRN-WB bearings have proved extremely successful in applications of this type.

3 WORM AND GEAR APPLICATION A double-row ball bearing is used for locating this shaft in both directions. The A-TS bearing at the opposite end is used with a cartridge that facilitates adjustment by shimming. Using a cylindrical bearing at one end facilitates assembly and permits easy removal of the worm from the case. Crowned rollers improve load carrying capacity and compensate for misalignment resulting from gear loads in shaft.

BEARINGS . . . AND NOBODY KNOWS THEM LIKE HYATT

YOU CAN RELY ON THE ADVICE OF YOUR HYATT SALES ENGINEER

...and the bearings he recommends!

You get the greatest benefit from HYATT engineering service when a HYATT representative is working closely with you on your bearing requirements. This service is available to you at any time. When you have questions that lend themselves to immediate answers, such as price, delivery or specifications of standard bearings, a telephone call can usually provide the necessary information.

just call your nearest **HYATT** *office:*

HARRISON, NEW JERSEY
427 Middlesex Street
Harrison, New Jersey • HUmboldt 4-4000

CHICAGO
332 S. Michigan Avenue
Chicago 4, Illinois • HArrison 7-8277

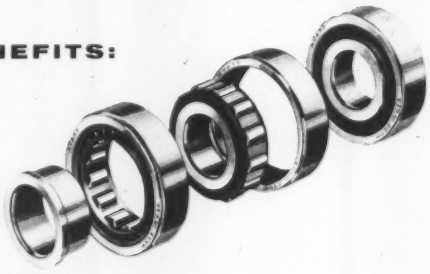
DETROIT
General Motors Building
Detroit 2, Michigan • TRinity 3-7200

PITTSBURGH
702 Grant Building
Pittsburgh 19, Pennsylvania • ATlantic 1-2927

OAKLAND
1419 Central Bank Building
Oakland 12, California • Twin Oaks 3-5362

REMEMBER THESE BUILT-IN HYATT BENEFITS:

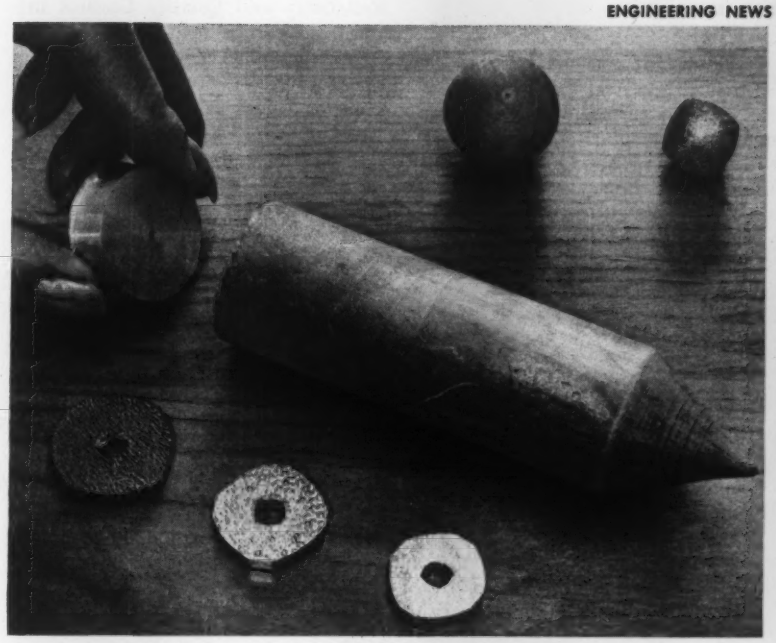
- Higher radial load-carrying capacity, size for size
- Minimum space requirements
- Omitted races are optional
- Shaft location without sacrificing capacity
- Easier assembly and disassembly
- Heavier press fits simplify retainment



THE RECOGNIZED LEADER IN CYLINDRICAL BEARINGS

HYATT HY-ROLL BEARINGS FOR MODERN INDUSTRY

HYATT BEARINGS DIVISION • GENERAL MOTORS CORPORATION • HARRISON, NEW JERSEY



Huge metal crystals, grown by the Bureau of Standards, furnish samples for corrosion study. Aluminum crystal discs corrode into different shapes, foreground, depending on the corrosive medium. Spherical specimen above bar corroded into shape shown, right, when exposed to an aqua regia-hydrofluoric acid mixture. Single-crystal studies are emphasized because in the single-crystal form a metal is in its least complicated state.

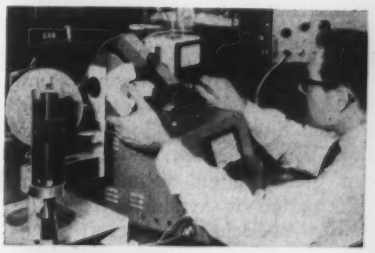
Attack on Rust Gets at the Basics

NBS Researchers Are Isolating Variables

WASHINGTON—Man has waged war on corrosion since he first discovered metals. But his successes are not impressive—rusted-out chariots plagued the Caesars and still fill junk piles today. In the pipeline industry alone, reliable estimates show the cost of replacement pipe exceeds $600 million per year. The annual cost of corrosion in the U. S. runs to billions of dollars.

Blaming lack of success on inadequate methods of attack, National Bureau of Standards scientists say stop-gap work solves only immediate problems, but does not get at the heart of the matter. The NBS answer: Researching mechanics and primary processes of corrosion.

Essentially, corrosion is process metallurgy *in reverse.* Iron occurs in nature as oxides and hydroxides, for example, and is refined to steels for structures and machine parts. When exposed to corrosive atmospheres, steel reverts to its original forms. Complex and costly, destruction of a metal by chemical or electrochemical reactions depends on many factors. NBS scientists are isolating and studying corrosion secrets from many angles:



Scientist monitors corrosion reactions on the surface of a single metal crystal with a polarizing spectrometer. Potentials and film thicknesses are measured, right, for a sample held in the apparatus, left.

- Corrosion in large single crystals
- Electrical effects—including electrochemical polarization
- Reactions at metal surfaces
- Stress-corrosion cracking
- Effects of free radicals on metals at low temperatures

While data are not yet in a usable form for industry, researchers

←Circle 418 on Page 19

Locking screws with LOCTITE increases production 23%

Assembling Hobbs Hour Meters

Mr. LeRoy L. Rasch
John W. Hobbs Div., Stewart-Warner Corp.
Springfield, Illinois, says:

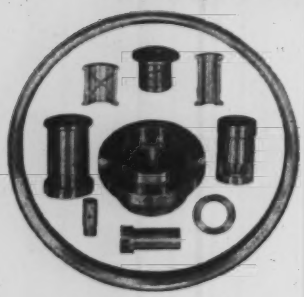
"We all try to cut costs. For example, we used a resin-type product to hold screws in assembling Hobbs Hour Meters. It was necessary for a girl to dip a little piece of wire into the compound, transfer it to the screw hole, and then assemble the screw. With 18 screws this was a slow and tedious job. We switched to LOCTITE Sealant and increased production while making the job easier for the girls. Operators now produce 23% more meters per hour thanks to LOCTITE! This increased production is accomplished by tumbling large batches of screws with LOCTITE in a polyethylene bag. The screws, treated and ready, are spread in front of the operator within easy reach. LOCTITE will not harden in air, but sets firmly when screws are assembled. LOCTITE saves us time and money by virtually eliminating the labor of applying the staking compound to the screws. LOCTITE cut costs for us with no effort at all."

LOCTITE is a thin liquid that hardens when confined between closely fitting metal parts. One drop replaces all size lock nuts, lock washers, lock screws, staking, jam nuts and interference threads. It forms a tough heat and oil resistant bond that resists any amount of vibration . . . yet ordinary tools will remove fasteners. LOCTITE requires no heating or mixing . . . treated parts can be stored for days . . . lock only when assembled. Write for literature and free sample.

LOCTITE® SEALANT
AMERICAN SEALANTS COMPANY
111 Woodbine St., Hartford 6, Conn.

Circle 419 on Page 19

A LITTLE STUBBORNNESS GOES INTO OUR SLEEVE BEARINGS



Producing bronze sleeve bearings requires more than special tools and techniques. It demands proven design experience such as we have acquired through 25 years of bronze bearing production. That's why we seem so insistent sometimes in our efforts to help with your bearing design. We have learned the hard way and are more than willing to share our experience with you. When we are convinced that a change will improve the bearing, cut production costs or ease assembly operations, you'll find our objections firm though constructive.

So if you would like experienced help with a particular bearing design problem—even to the recommendation of the proper alloy — be sure to take advantage of our specialized knowledge. We offer a full range of sizes in both cast and sintered bronze bearings including grooved and graphited items. In fact, it's the largest variety of bronze bearings available anywhere.

Would you like some useful information for your files? See the coupon below.

A Founding Member—
Cast Bronze Bearing Institute

RENEWAL SERVICE INC.
1705 Lehigh Ave., Phila. 32, Pa.

Send me "Chemical and Physical Specifications of the Bronze Alloys" which includes MIL., SAE, Navy, Aero., ASTM, and Fed. Spec. Comparatives.

Name_____

Company_____

Address_____

Renewal Service INC.

Circle 420 on Page 19

are convinced that carbon dioxide in the air, crystal orientation on the metallic surface, purity of the metals, and amount of light present all affect corrosion rates. In the future, they hope to extend this work and also study corrosion inhibitors. Kinetics and energy associated with reactions and forces involved will all be determined.

Meetings and Shows

Dec. 7-11—

National Conference on the Application of Electrical Insulation to be held at the Sheraton-Park Hotel, Washington, D. C. Sponsors are American Institute of Electrical Engineers and National Electrical Manufacturers Association. Additional information can be obtained from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

Dec. 8-9—

First Aerospace Finishing Symposium to be held at the Hotel Texas, Fort Worth. Sponsors are the Society of Aircraft Materials and Process Engineers and the Dallas-Fort Worth branch of the American Electroplaters Society. Further information is available from the Southwest Society of Aircraft Material & Process Engineers, 1026 South Adams, Fort Worth, Texas.

Dec. 14-15—

Material Handling Institute Inc. Annual Meeting to be held at the Savoy-Hilton Hotel, New York. Further information is available from Hanson & Shea Inc., 1 Gateway Center, Pittsburgh 22, Pa.

Dec. 17—

Institute of the Aeronautical Sciences. Wright Brothers Lecture to be held at the Natural History Bldg. Auditorium, Smithsonian Institution, Washington, D. C. Further information is available from IAS headquarters, 2 E. 64th St., New York 21, N. Y.

Jan. 11-13—

Sixth National Symposium on **Reliability and Quality Control in Electronics** to be held at the Statler Hilton Hotel, Washington, D. C. Sponsors are Institute of Radio Engineers, American Society for Quality Control, Electronic Industries Association, and American Institute of Electrical Engineers. Additional information can be obtained from IRE headquarters, 1 E. 79th St., New York 21, N. Y.

Jan. 12-15—

Society of Plastics Engineers. Annual Technical Conference to be held at the Conrad Hilton Hotel, Chicago. Further information can be obtained from Mr. T. A. Bissell, Executive Secretary, SPE, 65 Prospect St., Stamford, Conn.

Jan. 15—

Malleable Founders Society. Semiannual Meeting to be held at the Hotel Sheraton - Cleveland, Cleveland. Further information is available from society headquarters, 781 Union Commerce Bldg., Cleveland 14, Ohio.

Jan. 20-22—

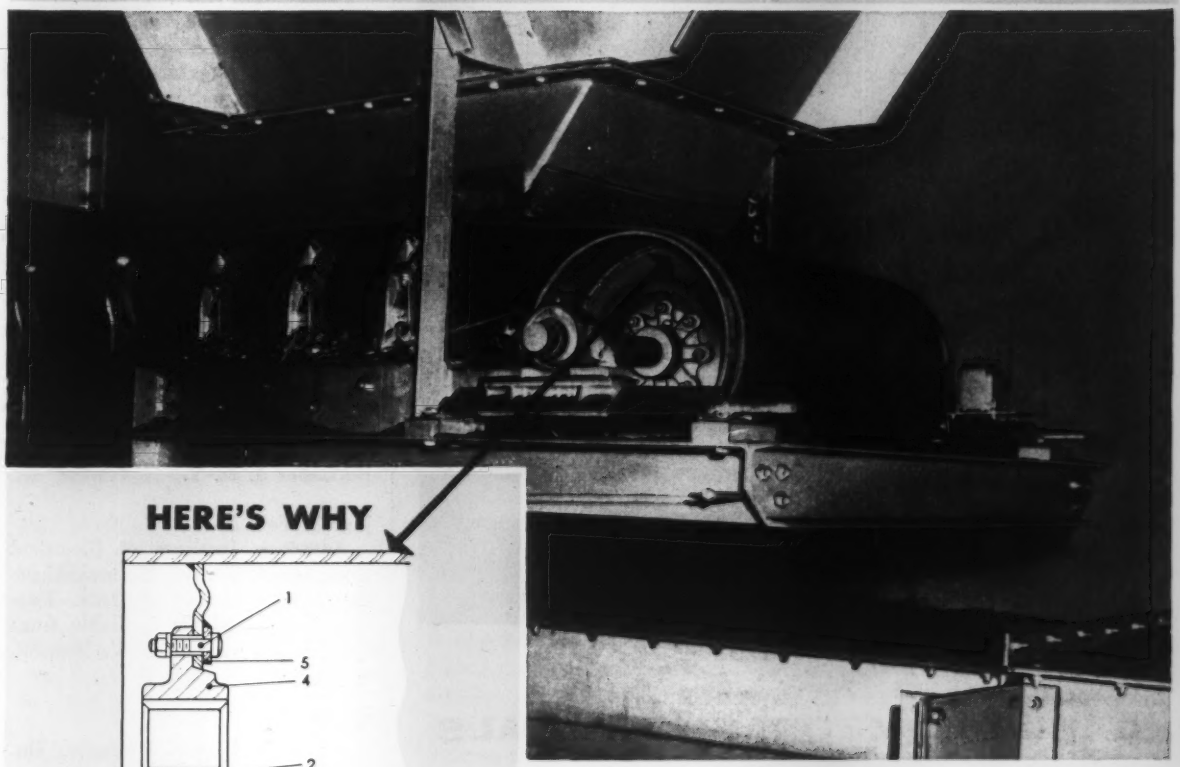
American Management Association. Conference on Utilizing Technology to be held at the Hotel Roosevelt, New York. Additional information can be obtained from AMA headquarters, 1515 Broadway, New York 36, N. Y.

Jan. 25-28—

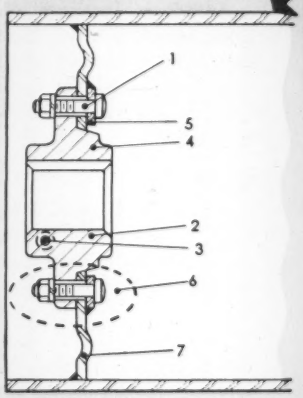
Institute of the Aeronautcial Sciences. Annual Meeting to be held

"I need $11.39 more a week!"

American Conveyor Pulleys save you money! Largest tonnage-dollar factor in the industry



HERE'S WHY



1. Long, high-tensile bolts store tension to keep nuts tight, hubs permanently in place; bolts do not carry load.
2. Hubs are saw-slit through one side to provide Wedg-Tite clamping action; they grip the shaft with a bulldog-like grip.
3. Cross-clamp bolts provide insurance that the hub will remain securely and permanently clamped to the shaft.
4. Massive hubs provide strength to withstand extreme loads.
5. Backing rings reinforce the end discs and reduce forces on the bolts on pulleys 10" diameter and up.
6. No welding in high-stress concentration area.
7. Corrugated end-discs, and clover leaf hub contour, eliminate stress concentrations in the high stress area.

$307.74* was saved on this installation on head and tail pulleys, shafts and bearings for a 48" belt conveyor moving 175 tons of coal per hour.

To figure the savings you can make on your installations, get a copy of the American Conveyor Pulley Catalog and engineering bulletin CP-47. Write for your copy.

Published Consumer Prices

POWER TRANSMISSION DIVISION

THE AMERICAN PULLEY COMPANY

4200 WISSAHICKON AVENUE · PHILADELPHIA 29, PA.

GARLOCK MECHANICAL SEALS

Easy to install—Garlock's PK MECHANIPAK* is self-contained—no parts to "put together." Rotating portion simply slides onto shaft; stationary portion positions quickly into counterbore of gland.

Easy to maintain—Once Garlock's PK MECHANIPAK is installed, further adjustment is unnecessary. No parts of the seal move on the shaft or sleeve, eliminating wear on shaft . . . spring in seal maintains contact between sealing faces.

Easily cuts costs—Garlock's PK MECHANIPAK is designed to reduce maintenance and downtime, thus offers many dollar-saving benefits.

Available in shaft sizes from $\frac{3}{8}$" to 3" . . . will operate at temperatures to 212°F, pressures to 150 psi, shaft speeds to 2000 fpm. PK MECHANIPAK Seals are another important part of the Garlock 2,000 . . . two thousand different styles of packings, gaskets, and seals for every need. Find out more from your local Garlock representative, or write for Catalog AD-150.

*Registered Trademark

THE GARLOCK PACKING COMPANY, Palmyra, N. Y.

For Prompt Service, contact one of our 26 sales offices and warehouses throughout the U.S. and Canada.

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Molded and Extruded Rubber, Plastic Products

Canadian Division: The Garlock Packing Co. of Canada Ltd., Plastics Division: United States Gasket Company

at Hotel Astor, New York. Further information is available from IAS headquarters, 2 E. 64th St., New York 21, N. Y.

Jan. 25-28—

Plant Maintenance and Engineering Conference to be held at Convention Hall, Philadelphia. (Conference dates are Jan. 25-27.) Further information can be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Jan. 26-27—

Society of Vacuum Coaters. Third Annual Meeting to be held at the Hotel Biltmore, New York. Technical sessions will be on Wednesday. Further information is available from John H. Smith, Application Engineer, Technical Services Dept., Consolidated Electrodynamics Corp., 1775 Mt. Read Blvd., Rochester 3, N. Y.

Jan. 31-Feb. 5—

American Institute of Electrical Engineers. Winter General Meeting to be held in New York. Further information is available from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

Feb. 1-4—

American Society of Heating, Refrigerating and Air-Conditioning Engineers Inc. Semiannual Meeting to be held concurrent with the Second Southwest Heating and Air-Conditioning Expositon, which is under the auspices of ASHRAE, in Dallas. Headquarters for the society meeting will be the Baker Hotel; the exposition will be in Memorial Auditorium. Further information is available from ASHRAE, 234 Fifth Ave., New York 1, N. Y.

Feb. 1-5—

Instrument Society of America. Instrument-Automation Conference and Exhibit to be held at the Coliseum, Houston, Tex. Further information can be obtained from ISA headquarters, 313 Sixth Ave., Pittsburgh 22, Pa.

Feb. 2-4—

Society of the Plastics Industry Inc. Fifteenth Reinforced Plastics Div. Conference to be held at the

Edgewater Beach Hotel, Chicago. Further information is available from SPI headquarters, 250 Park Ave., New York 17, N. Y.

Feb. 3-4—

Midwest Welding Conference to be held at Illinois Institute of Technology, Chicago. Sponsors are Armour Research Foundation and the Chicago section of the American Welding Society. Additional information can be obtained from Harry Schwartzbart, Supervisor of Welding Research, Armour Research Foundation, 10 W. 35th St., Chicago 16, Ill.

Feb. 3-5—

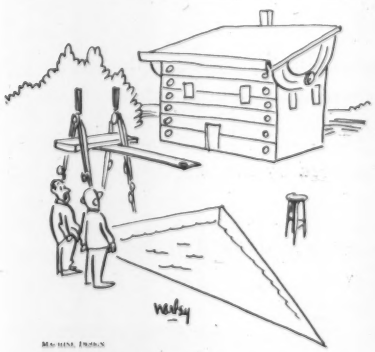
Institute of Radio Engineers. Winter Convention on Military Electronics to be held at the Biltmore Hotel, Los Angeles. Additional information can be obtained from IRE headquarters, 1 E. 79th St., New York 21, N. Y.

Feb. 14-18—

American Institute of Mining, Metallurgical, and Petroleum Engineers. Annual Meeting to be held at the Statler-McAplin Hotel, New York. Further information is available from AIME headquarters, 29 W. 39th St., New York 18, N. Y.

Feb. 18-20—

National Society of Professional Engineers. Winter Meeting to be held at the Broadview Hotel, Wichita, Kans. Additional information can be obtained from NSPE headquarters, 2029 K St. N.W., Washington 6, D. C.



"I understand he made all his money in drafting equipment."

CAUSTIC SOLUTION

A CASE IN POINT—This is a 19 pound Ni-Resist valve body designed to handle caustic fluids at 400 psi. It was cast for the John Bean Division of Food Machinery & Chemical Corp. Ni-Resist is ideal for this application because it combines high corrosion resistance with superior resistance to erosion from high velocity fluids.

The intricate coring required demands unusual skill to produce Ni-Resist castings leak-proof at 400 psi operating pressures. Hamilton Foundry succeeded in producing pressure tight castings, an accomplishment difficult for the best of foundry men.

When new and unusual design problems arise in the selection of metal and the casting of parts, you will find that the skill and integrity of your foundry is your best insurance that specifications—and delivery schedules—will be met.

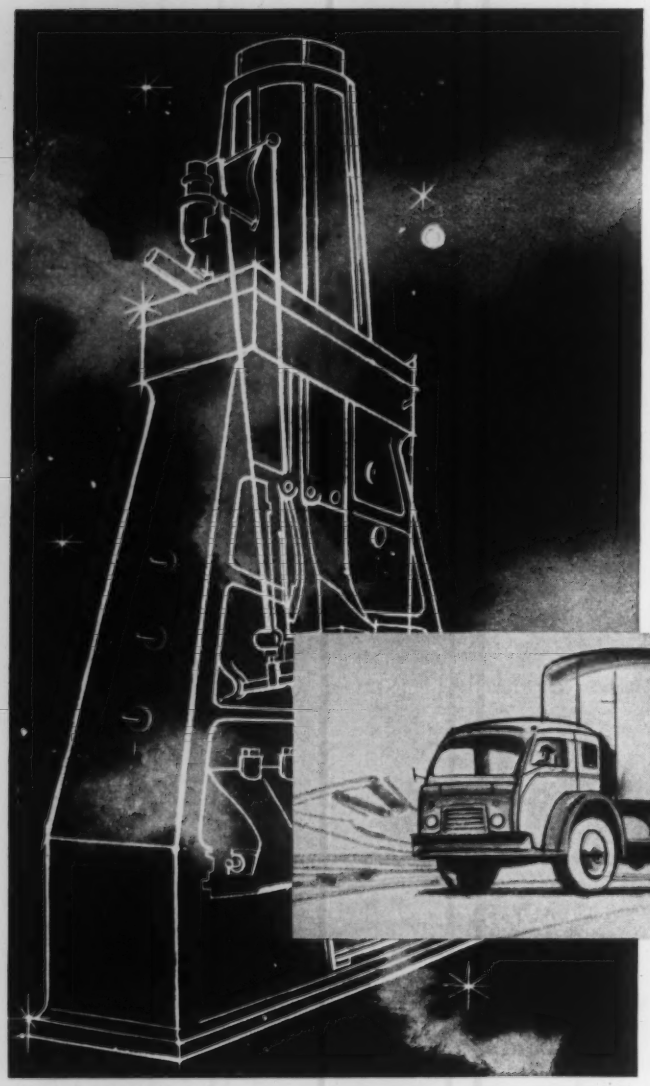
GRAY IRON • ALLOYED IRON • MEEHANITE® • DUCTILE (NODULAR) IRON • NI-RESIST • DUCTILE NI-RESIST • NI-HARD

H

HAMILTON FOUNDRY INC.

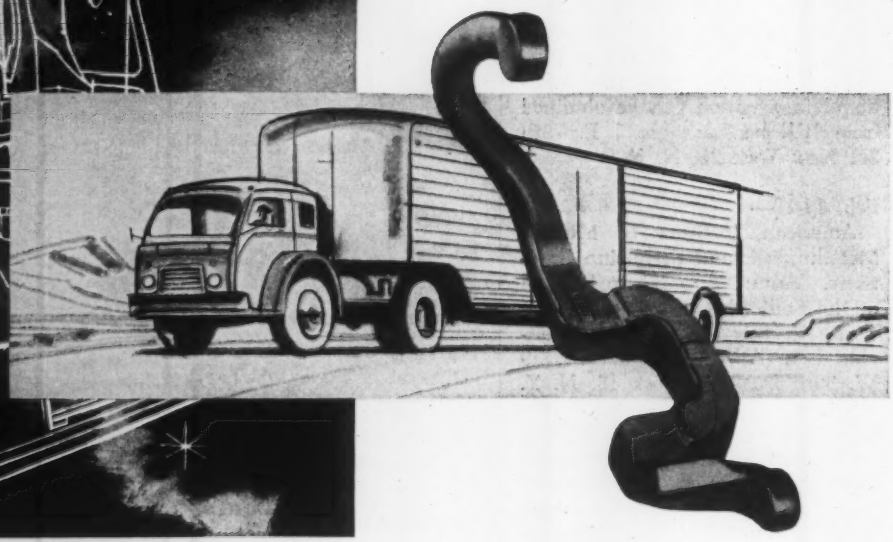
1551 LINCOLN AVENUE • HAMILTON, OHIO • TWinbrook 5-7491

Circle 423 on Page 19



Typical steam forging hammer

REQUIRED SAFETY FACTORS in steering arm assured by designing it to be forged



By designing with forgings, a truck manufacturer can count on the required safety factors, with minimum "beefing-up" of parts to offset unknown internal structures or non-homogenious materials.

You, too, can achieve results like these by designing *with forgings* either at the start or on re-design. The benefits of forgings are equally impressive, whether you make home-workshop equipment or diesel engines.

Forgings start as *better* metal . . . are further *improved* by the hammer-blows or high pressure of the forging process.

Write for literature on the design, specification, and procurement of forgings.

When it's a vital part, design it to be FORGED

Drop Forging Association • Cleveland 13, Ohio

Names of sponsoring companies on request to this magazine

Bruning's new Copyflex Model 440 gives you everything you've most wanted in a reproduction machine—at the lowest price ever!

You get a spacious 42″ printing width, powerful 4,000 watt lamp, and a mechanical speed of 40 f.p.m. . . . plus such conveniences as automatic separation, a foot lever for releasing incorrectly fed stock, adjustable front print tray, automatic tracing stacker, new air filtering system that assures cleaner prints, and a pressure-roller developer system that provides positive print development at all speeds. The 440 is equipped for roll stock, provides selective front or rear print delivery. Like all Bruning built Copyflex machines, it's odor-free, durable, and dependable. You have everything to gain by mailing the coupon.

Charles Bruning Company, Inc. Dept. 11-x
1800 Central Road, Mt. Prospect, Illinois
Offices in Principal U.S. Cities
In Canada: 103 Church St., Toronto 1, Ontario

☐ Please send me information on your new low-cost Model 440.

Name_____ Title_____

Company_____

Address_____

City_____ County_____ State_____

The Bruning man is your expert on diazo reproduction. He's backed by a company with over sixty years' experience.

Circle 425 on Page 19

Aeroquip's Extensive Product Lines

Fluid Piping

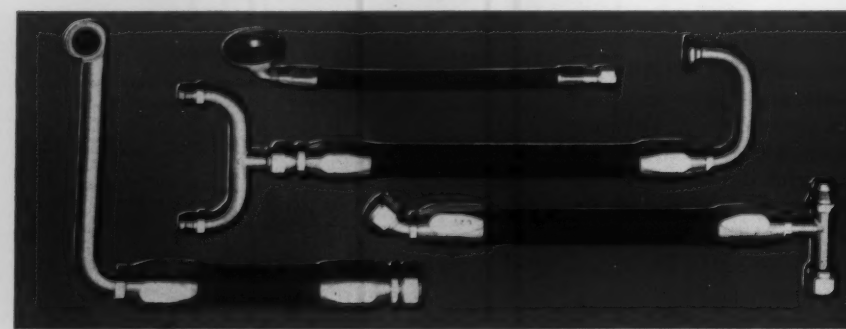
Highly qualified Aeroquip Sales Engineers are on call to furnish design assistance right in your engineering department. They follow through to assist at other stages of manufacture where Aeroquip's unmatched fluid line experience can also help you.

Aeroquip Field Engineers work with your engineers in building prototypes, assisting in fluid system test and modification.

Skilled Aeroquip Sales Engineers assist in various production planning functions, make time-saving and money-saving recommendations.

Aeroquip Service Engineers are trained troubleshooters who can analyze fluid systems under field conditions to verify system performance.

Experienced Aeroquip personnel work closely with your parts or service people to develop a service parts program to your exact requirements.



UNLIMITED RANGE OF AEROQUIP FLUID PIPING ASSEMBLIES

Fluid piping assemblies like these can decrease the number of components required, producing highly simplified and trouble-free fluid systems on your equipment.

And Facilities Provide Complete Service For Equipment Manufacturers

- DESIGN
- PROTOTYPE
- PRODUCTION
- FIELD SERVICE
- SERVICE PARTS

Aeroquip's unequaled experience in solving fluid piping problems has helped many equipment manufacturers save time and money. This experience is presented to you as the Aeroquip Fluid Piping Service. This unique service is available to any qualified equipment manufacturer desiring assistance in any and all phases of design, development or manufacture, as listed above.

Highly skilled Aeroquip sales and service engineers are available to work with you, in your plant or in the field. Backed by the most complete line of fluid piping products and extensive engineering and manufacturing facilities, these specialists can help you solve any fluid line problem. In many cases, solving the problem results in simplification of a fluid system or fluid systems to a point where fewer component parts are required. This can cut material costs, reduce ordering, stocking and processing requirements.

If you would like more information on the Aeroquip Fluid Piping Service, please write to us.

Write Today for Your Copy of Bulletin 614 Describing the Benefits of the Aeroquip Fluid Piping Service.

Aeroquip

REG. TRADEMARK

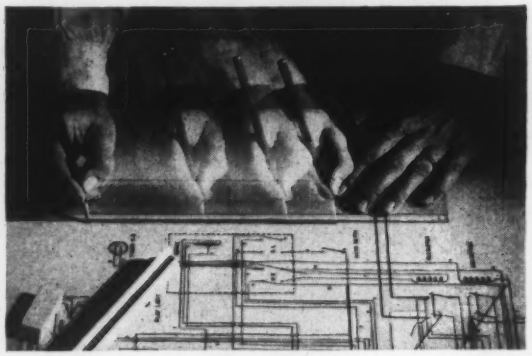
AEROQUIP CORPORATION, JACKSON, MICHIGAN

Circle 427 on Page 19

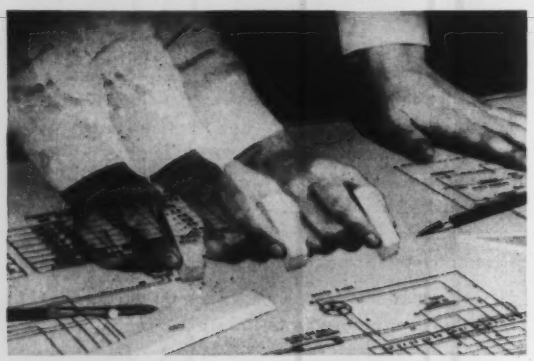
NEW! CRONAFLEX® DRAFTING FILM

The best surface on the toughest base . . . made and controlled by Du Pont from start to finish.

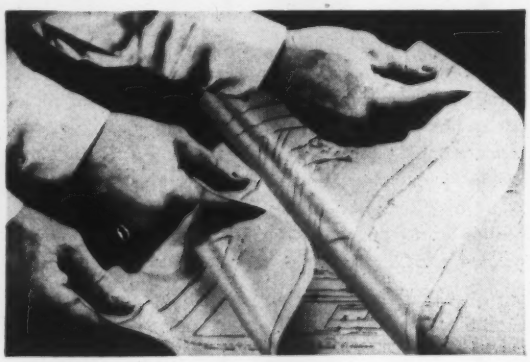
1 CRONAFLEX Drafting Film has excellent pencil acceptance. Its superb matte surface accepts printing and drafting inks.



2 CRONAFLEX Drafting Film erases easily, without ghosting, yet there is less smudging. It comes matted one or two sides, and is available in either rolls or sheets.



3 CRONAFLEX Drafting Film is .004" thick, which has been found to be ideal for drafting. Its rugged CRONAR* polyester film base will take repeated handling and countless trips through your reproduction machine and to and from your file drawer without cracking or becoming brittle. It lies flat, holds size, is flexible and impervious to moisture.



CRONAFLEX Drafting Film is the first product of its kind which is made in its entirety by a single manufacturer. The benefits can be summed up in two words: quality control. We control the manufacture of both base and surface, and we control the method by which they are made into the best drafting film you can buy.

This means that every sheet of CRONAFLEX Drafting Film has the same excellent pencil acceptance, the same erasability, the superb matte surface, the .004" thickness which has been found ideal for drafting and filing.

If drawings are made anywhere in your operation, you can use CRONAFLEX Drafting Film to great advantage. CRONAFLEX Drafting Film joins the widely acclaimed CRONAFLEX line of films: Direct Positive, Contact and Projection. You can go from original drawing to final reproduction with the same product line on the same strong base. For more information write: E. I. du Pont de Nemours & Co. (Inc.), Photo Products Department, Wilmington 98, Delaware. In Canada: Du Pont of Canada Limited, Toronto.

DU PONT
REG. U. S. PAT. OFF.

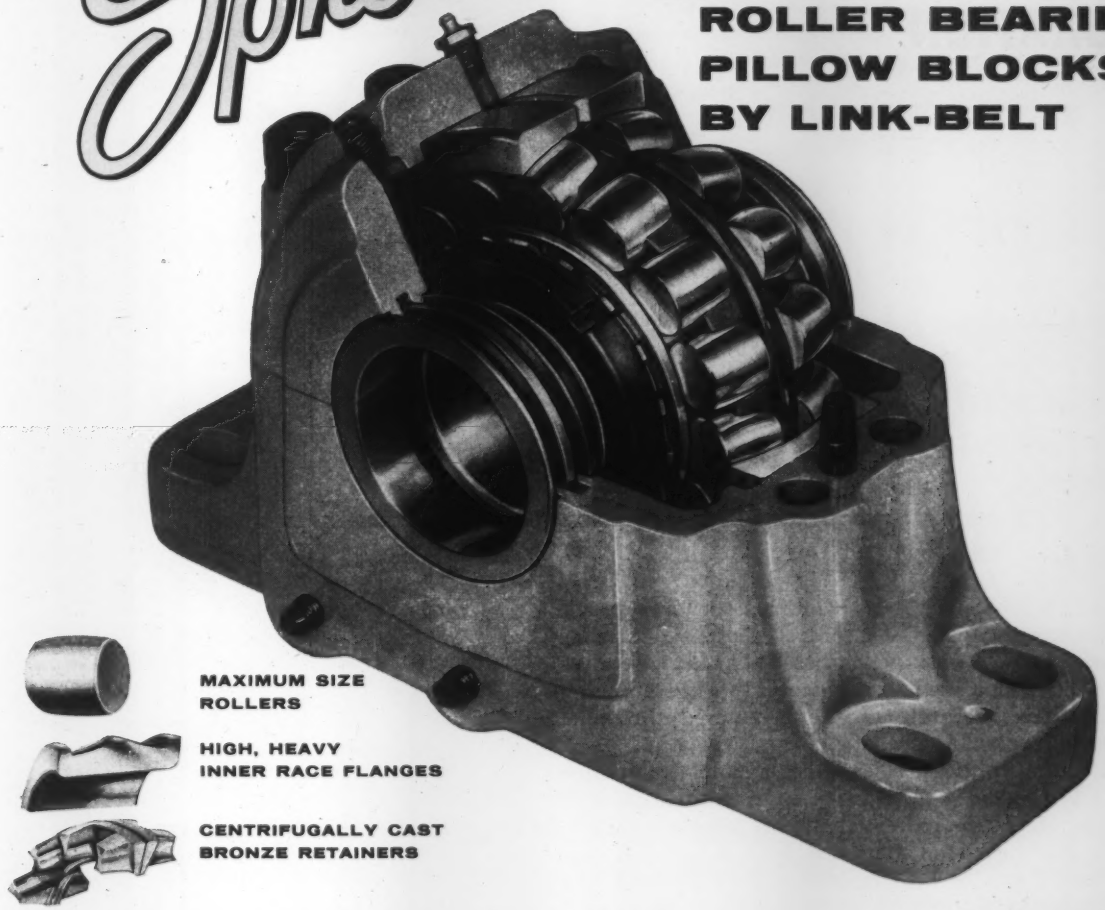
BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

**Du Pont's trademark for its polyester photographic film base.*

The best features of modern bearing design — combined and refined in

Spherical

ROLLER BEARING PILLOW BLOCKS BY LINK-BELT



MAXIMUM SIZE ROLLERS

HIGH, HEAVY INNER RACE FLANGES

CENTRIFUGALLY CAST BRONZE RETAINERS

Series 6800, 6900, 7800, 7900 roller bearing pillow blocks have spherical roller bearings with internationally standardized boundary dimensions.

Big, mirror-smooth, convex rollers . . . hefty inner race flanges . . . centrifugally cast bronze, precision-machined retainers. They're industry's *preferred* bearing features. And they're *all* found in Link-Belt's new spherical roller bearing . . . compactly combined in an exceptionally durable two-piece housing.

These self-aligning roller bearing pillow blocks take misalignment in stride—adjust immediately in any direction while maintaining full load capacity. Two types of shaft mountings facilitate installation . . . adapter mounting for commercial shafting and direct shaft mounting for shafting ground to recommended tolerances. And Link-Belt's rugged steel multi-labyrinth or dacron-contact seals lock out dirt, lock in lubricant.

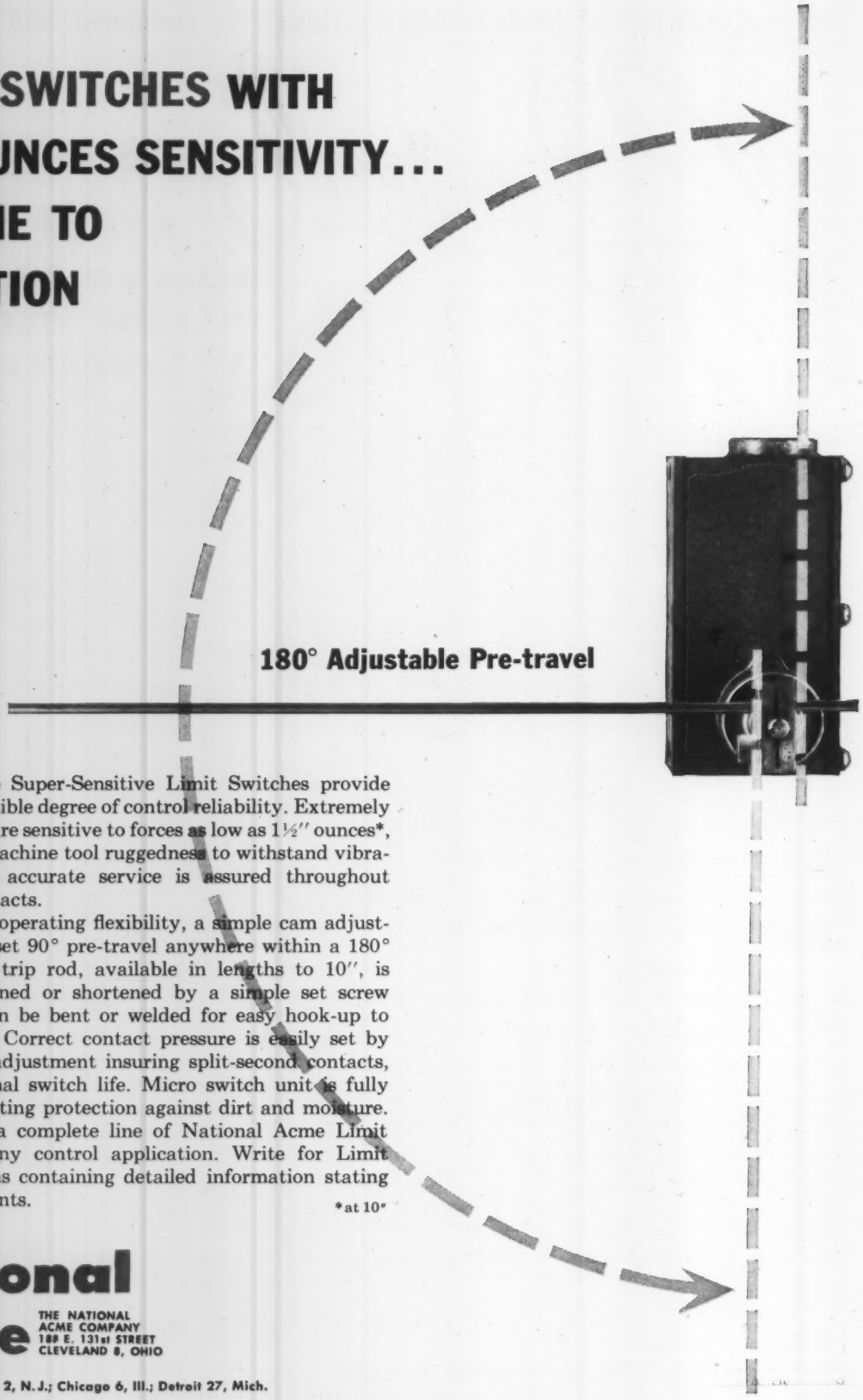
For details, call your Link-Belt office and ask for new 52-page Book 2760. Look under BEARINGS in the yellow pages of your phone book.

LINK-BELT

SELF-ALIGNING BALL AND ROLLER BEARINGS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 15,161-A

LIMIT SWITCHES WITH 1½″ OUNCES SENSITIVITY... IMMUNE TO VIBRATION



National Acme Super-Sensitive Limit Switches provide the highest possible degree of control reliability. Extremely compact, they are sensitive to forces as low as 1½″ ounces*, and yet have machine tool ruggedness to withstand vibration. Reliable, accurate service is assured throughout millions of contacts.

For extreme operating flexibility, a simple cam adjustment lets you set 90° pre-travel anywhere within a 180° arc. The steel trip rod, available in lengths to 10″, is readily lengthened or shortened by a simple set screw adjustment; can be bent or welded for easy hook-up to other linkages. Correct contact pressure is easily set by a steel spring adjustment insuring split-second contacts, ten times normal switch life. Micro switch unit is fully enclosed for lasting protection against dirt and moisture.

Select from a complete line of National Acme Limit Switches for any control application. Write for Limit Switch Bulletins containing detailed information stating your requirements.

*at 10″

National Acme

THE NATIONAL ACME COMPANY
188 E. 131st STREET
CLEVELAND 8, OHIO

Sales Offices: Newark 2, N.J.; Chicago 6, Ill.; Detroit 27, Mich.

1 This bottle molded of tough polyethylene carries:
(a) alkali *(b) acid for dry-shipped batteries*
(c) water

2 They're big and juicy when polyethylene film is used for:
(a) packaging *(b) mulching*
(c) hothouse glazing

Can you pass this test on Polyethylene Plastics?

(You'll discover more of their potential as design materials)

3 It's the new Atlantic cable, insulated with polyethylene for:
(a) dielectric strength *(b) flexibility*
(c) underwater identification

4 This muffin box is coated *inside* with polyethylene to:
(a) make it moisture-proof *(b) prevent grease staining*
(c) please the housewife

5 The familiar garbage can—a product polyethylene modernized:
(a) three ways *(b) four ways*
(c) five ways

ANSWERS... *to an increasing range of needs are found in BAKELITE polyethylene plastics.*

1. (b) Battery acid—unbreakable polyethylene bottles are inert to almost all chemicals.
2. (b) The mulch controls weed growth, keeps soil moist, berries off ground. Hothouse glazing and packaging could help too.
3. Check (a) and (b). It's water-proof, too, of course.
4. (a) and (b) are right—so (c) is a natural.
5. (c) Five important ways—non denting, light weight, integral color, less noise, and resistance to chemicals.

If you have questions —about designing with plastics for function, serviceability, economy and appearance—please ask us. We'll be glad to answer on the practical design and engineering uses of vinyls, epoxies, phenolics, styrenes, and polyethylenes. Just write or call any of our offices or write Dept. KW-02D, Union Carbide Plastics Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. *In Canada*: Union Carbide Canada Limited, Toronto 7.

UNION CARBIDE

"Bakelite" and "Union Carbide" are registered trade marks of Union Carbide Corporation.

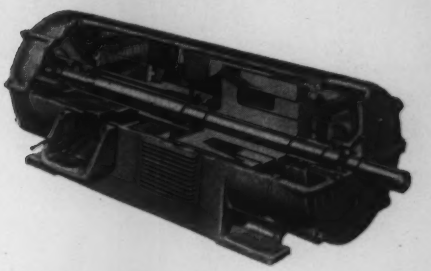
What do you need in an adjustable speed drive?

Better Regulation!

Compactness!

Less Maintenance!

7½-hp Ajusto-Spede Drive



Common motor-drive housing for units up to 7½ hp saves space — can be foot or flange mounted. Larger sizes up to 100 hp with individual motor and drive housings mounted integrally.

NEW design news from Louis Allis

...The Louis Allis AJUSTO-SPEDE® drive is more compact, precise, and trouble-free

Here's an adjustable speed drive that allows *truly precise* machine operation. Speed regulation is automatic and stepless — results in faster, more efficient production at lower cost, with less waste, and minimum wear on equipment.

These and other benefits are yours when you use the improved Louis Allis Ajusto-Spede drive. For example, it can be set before or during operation to deliver any desired speed within its range. Its *exclusive* tachometer feedback circuit monitors the output speed and *automatically corrects speed and holds it* regardless of load changes.

This improved drive requires minimum maintenance. Its stationary field has no brushes, commutators, or slip rings to cause trouble. The source of power is an equally trouble-free standard a-c squirrel cage motor. The cast-iron housing keeps out dirt, chips, and moisture — resists corrosion.

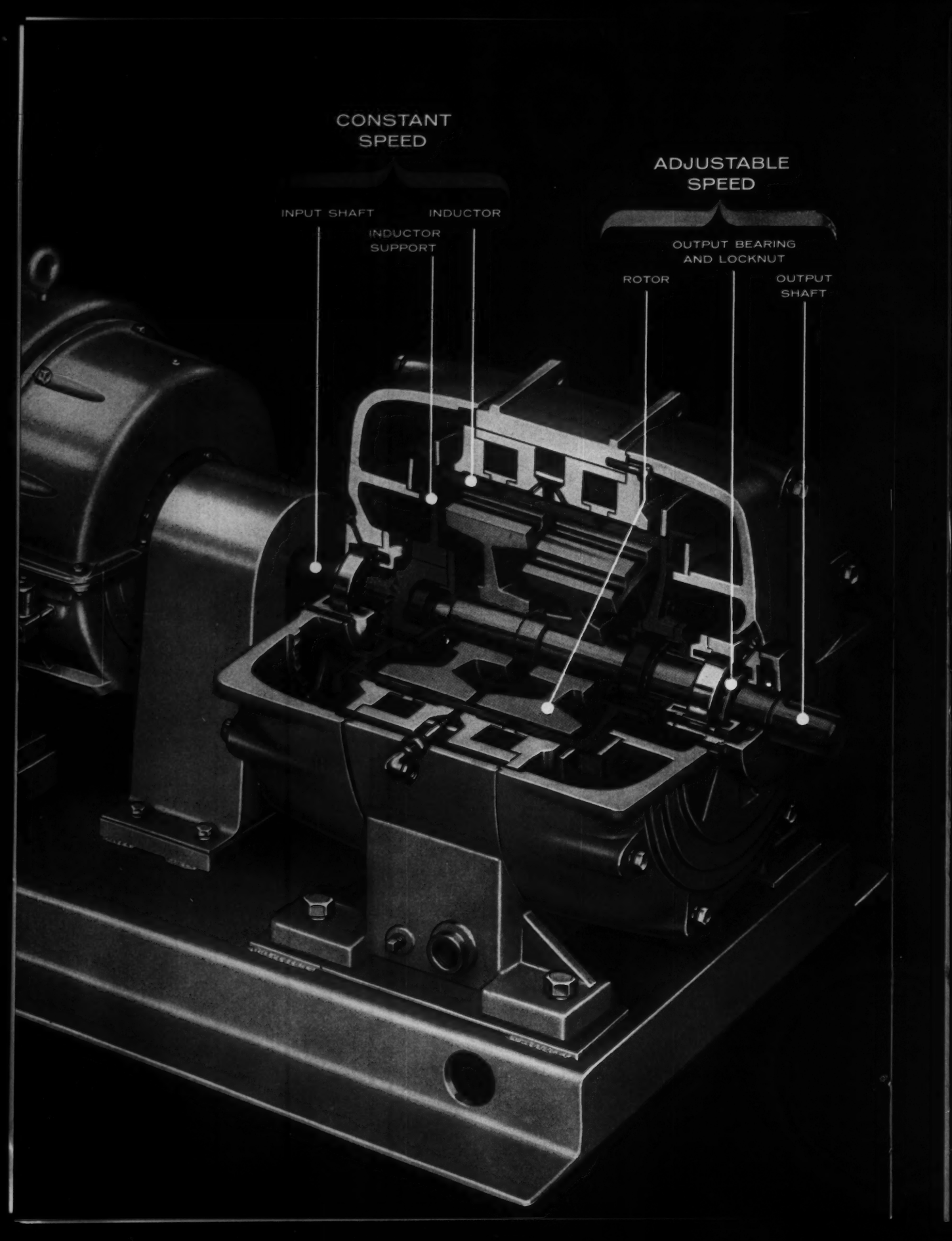
The compact Ajusto-Spede also saves space. Integrally-mounted motor and drive simplify handling — can be easily adapted for installation on new or existing machines. Controls can be mounted at the machine or any other convenient position.

The Louis Allis Ajusto-Spede drive is the practical solution to almost every application that requires dependable, easily controlled adjustable speed. It is the answer to precise operating speeds for machine tools, process machinery, test equipment, windups, conveyors, printing presses, and other equipment. Contact your Louis Allis District Office for information and application help. Or write for bulletins 2750 and 2800 — The Louis Allis Co., 459 East Stewart Street, Milwaukee 1, Wisconsin.

® Ajusto-Spede is a registered trademark of the Eaton Mfg. Co.

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

LOUIS ALLIS


CONSTANT SPEED
ADJUSTABLE SPEED
INPUT SHAFT
INDUCTOR
INDUCTOR SUPPORT
OUTPUT BEARING AND LOCKNUT
ROTOR
OUTPUT SHAFT

Another new product from Louis Allis

Just a few of many application possibilities:

- Test stands
- Adjustable-frequency sets
- Paper-machine drives, line shaft, sectional, or helper
- Extruder drives
- Rubber and paper calenders
- Wire-drawing machines
- Pumps and blowers
- Kiln drives

The new Louis Allis MAGNETIC DRIVE

A compact, precise adjustable speed drive up to 2000 hp!

If you use adjustable speed drives up to 2000 hp, you ought to know about the special features available in the *all-new* Louis Allis Magnetic Drive. Based on a liquid-cooled magnetic coupling design, this outstanding drive offers you the finest in precise regulation, compactness, and design flexibility.

A unique annular cooling manifold distributes the coolant over the outer surface of the inductor drum to provide an effective heat transfer. "Water drag" is eliminated, since there is *no* liquid in the air gap between the constant speed and adjustable speed members.

This new cooling principle eliminates "flooding" the Magnetic Drive and forcing of water into the bearings. And you'll never find condensation in the bearings, because the annular manifold design permits a planned flow of air through the drive at all times. This reduces bearing temperature and carries away any condensation which might occur as the unit cools off after use.

The design also incorporates stationary field construction, thus eliminating slip rings. All bearings can be easily lubricated without disassembly, and grease chambers provide ample grease reservoirs.

Other features include field coils and lead connections encapsulated in a special chemical and heat-resistant polyester — simplified construction for easy inspection and servicing — and versatile design for simple relocation of cooling inlet, conduit box, discharge, etc., regardless of direction of rotation.

If your plans call for adjustable speed drives — specify Louis Allis Adjustable Speed Magnetic Drive. For a complete description of these new drives, write for Bulletin 3650 — now available at your Louis Allis District Office or from The Louis Allis Co., 459 East Stewart Street, Milwaukee 1, Wisconsin.

Two-field construction shown. Also built in one, three, or four-field construction with or without magnetic brakes. Simply specify your hp and speed requirements and Louis Allis will tailor the drive to your need.

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

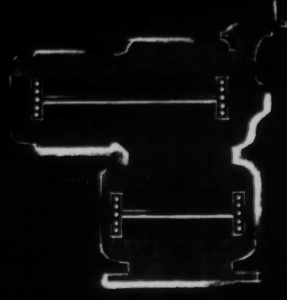
Circle 433 on Page 19

LOUIS ALLIS

ASD-132

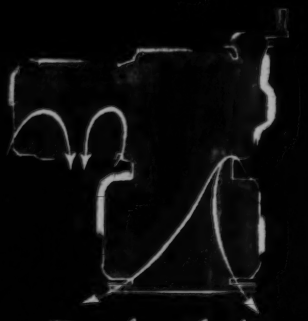
Field Versatility

Mounting feet, end brackets, control hand wheel, conduit box, and output shaft can be relocated in minutes without special tools for wall-, floor- or ceiling mounting. Components can be changed or controls can be added in the field to meet ever-changing conditions of operation.



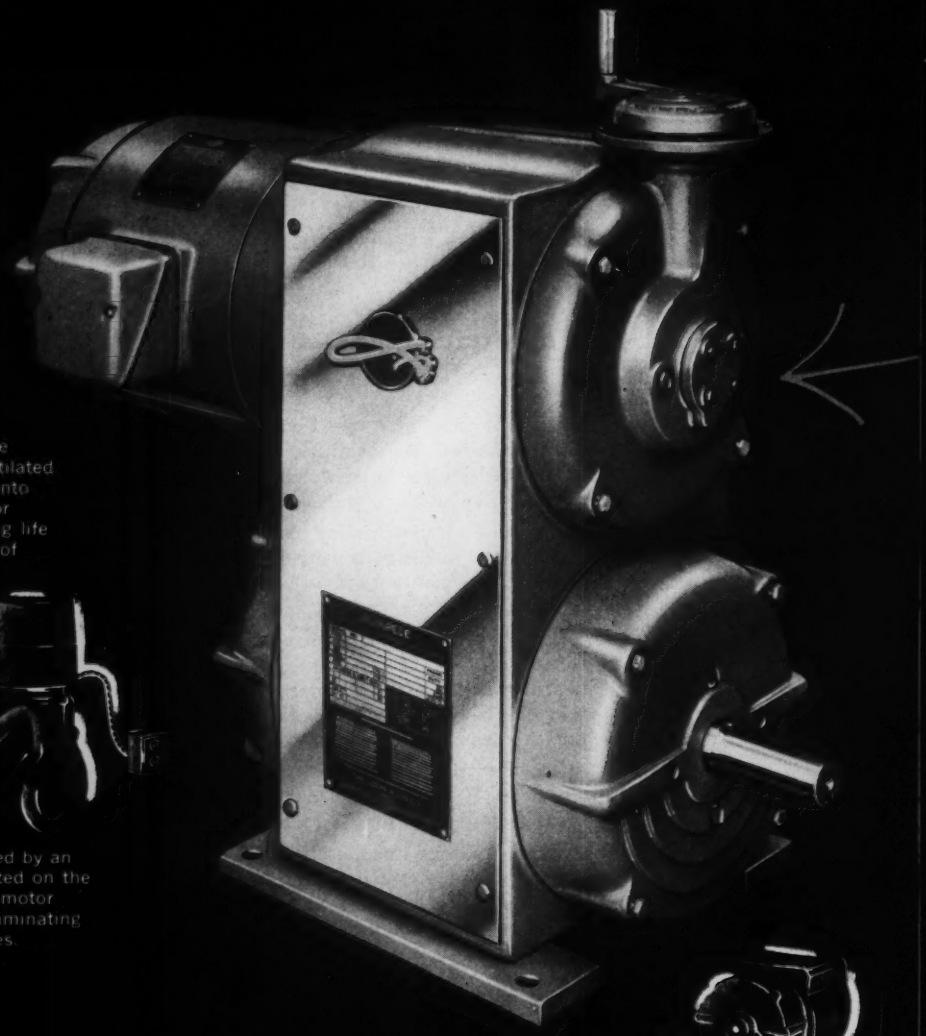
Four-Bearing Design

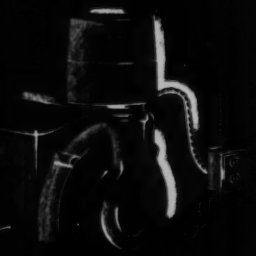
This important design feature eliminates the problems of overhung discs. It equalizes distribution of belt loading — keeps bearings, shafts, discs and belt permanently aligned — improves performance — and extends bearing life.



Dual-Ventilation System

The motor and the belt housing of the ALLISPEDE DRIVE are individually ventilated. Motor ventilating air is not exhausted into the belt housing — belts run cooler for longer life. Service factor and operating life of all components are higher because of lower operating temperatures.





Trouble-Free Remote Control

Electrical remote control can be provided by an enclosed speed-adjusting motor, mounted on the belt changing mechanism. This torque motor can be stalled without overheating, eliminating the need for troublesome limit switches.

Long Belt Life

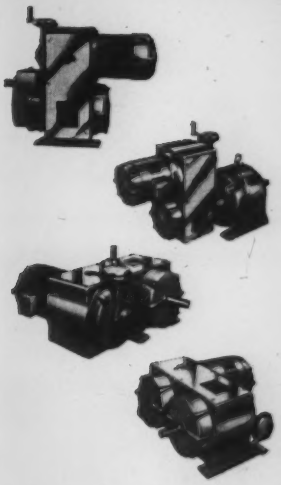
Single-cog belts with extra contact area provide more efficient transmission of power and longer belt life. Dual ventilation, precision-machined discs, equalized loading, and automatic belt tension aid in extending belt life.

Fast Belt Changing

Belt changing is fast and easy — without requiring special tools. You remove only one bearing bracket and the speed-adjusting mechanism to make fast changes without affecting permanent alignment of discs or belts.

Remote Speed Indication

A tachometer generator mounted on the output shaft operates an indicator that can be mounted at a remote location. Disassembly of the tachometer is not required when making belt changes.



Four of the many variations of mounting available with the ALLISPEDE DRIVE.

Another new product from Louis Allis

Let's look at the features of the

ALLISPEDE DRIVE*

New Louis Allis Drive offers accurate control – maximum belt life – long-run economy – low-cost versatility – ease of installation

After checking the many superior features of this drive, you will prefer the Allispede every time. The illustrations at the left demonstrate the many advantages of design and construction available in this drive.

The Allispede Drive gives you high efficiency and close regulation. Belt tension adjusts automatically — and belt changes are easy and fast. The modern design eliminates overhung discs—maintains belt and disc alignment — results in longer belt life — provides the ultimate in field versatility.

Check the accompanying features — *now!* A phone call to your local Louis Allis District Office will bring a skilled Louis Allis Field Engineer. He will gladly study your drive problem and offer Application Engineering assistance. Or write to Louis Allis Company, 459 East Stewart Street, Milwaukee 1, Wisconsin for a copy of Bulletin 3600.

*ALLISPEDE is a trademark of The Louis Allis Company.

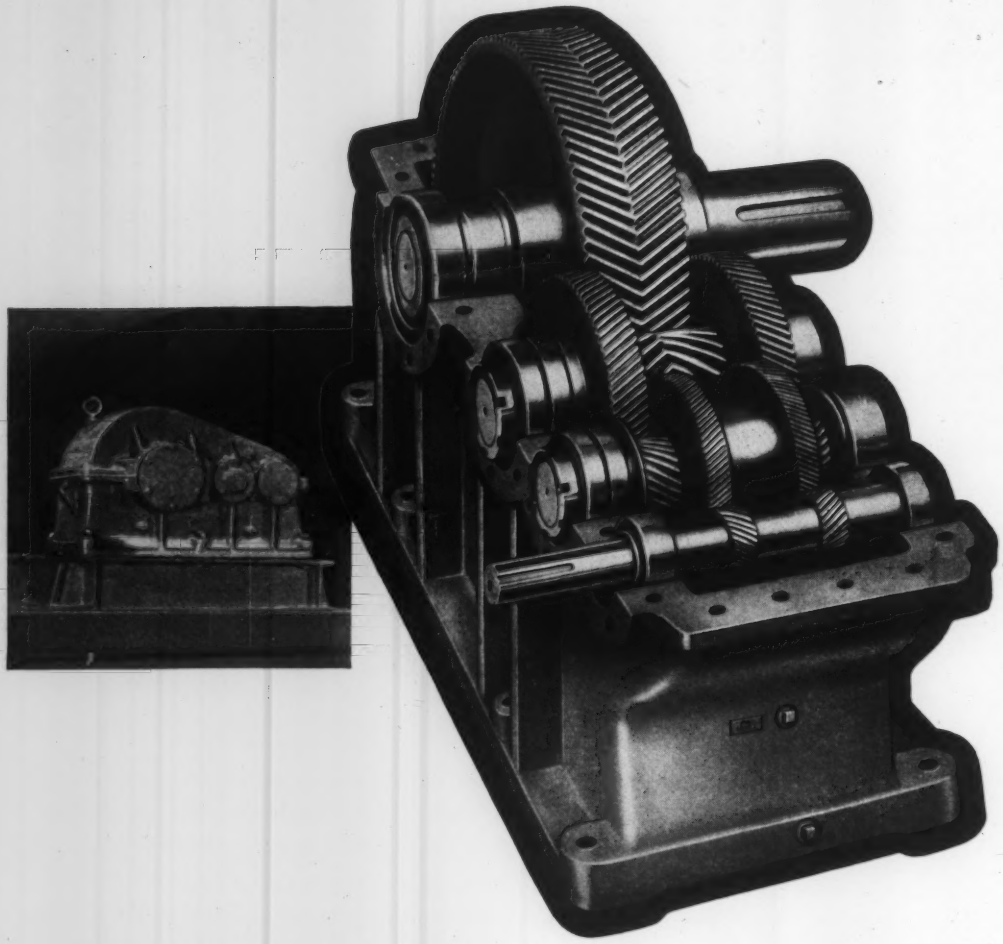
The Complete Line–

Whatever your mechanical drive application requirements, there's an ALLISPEDE DRIVE to match it exactly. Sizes up to 30 HP, output speeds from 1 to 10,000 RPM, and speed ranges up to 8:1. Motors can be open, drip-proof, enclosed, or explosion-proof; with ventilated or enclosed belt housings, suitable for foot, P-base, C- or D-flange mounting on your machine. Available with parallel shaft, or right-angle, integral gear reducers, special shaft extensions, integral magnetic brakes, electrical or mechanical remote control, and other modifications as required to meet the specifications of your application.

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

LOUIS ALLIS

Circle 434 on Page 19



THE HEAVIER THE LOAD . . . THE MORE YOU NEED

PHILADELPHIA HERRINGBONE REDUCERS

Heavy repeated shock loads . . . high horsepower . . . round-the-clock operation . . . put them together and you have the kind of a job where Philadelphia Herringbone Reducers perform best. They will last longer and save your maintenance dollars because extra strength is built into every part . . . housings, shafting, bearings and gearing.

To be specific:

Housings are specially reinforced at points of greatest stress. Extra heavy bearings take shocks and heavy overhung loads in stride. Result: shaft alignment is accurate . . . and it stays accurate. Gears, pinions and bearings last longer.

To meet the specific needs of each application, gearing is specially designed and symmetrically arranged in the housing. Result: the bearings on each shaft carry equal loads, shaft deflections are minimized, bearings and gearing have higher shock load capacity.

Pound for pound, horsepower for horsepower and dollar for dollar, you can't buy a herringbone reducer that will outlast a Philadelphia. They are designed with *your* heavy duty drive problems in mind . . . so that you will never have a drive problem.

Philadelphia Herringbone Reducers are available in single, double and triple reduction for ratios of 1.75:1 to 292:1. Write today for your copy of Catalog H-55.

PHILADELPHIA GEAR CORPORATION

Erie Avenue and G Street • Philadelphia 34, Pennsylvania

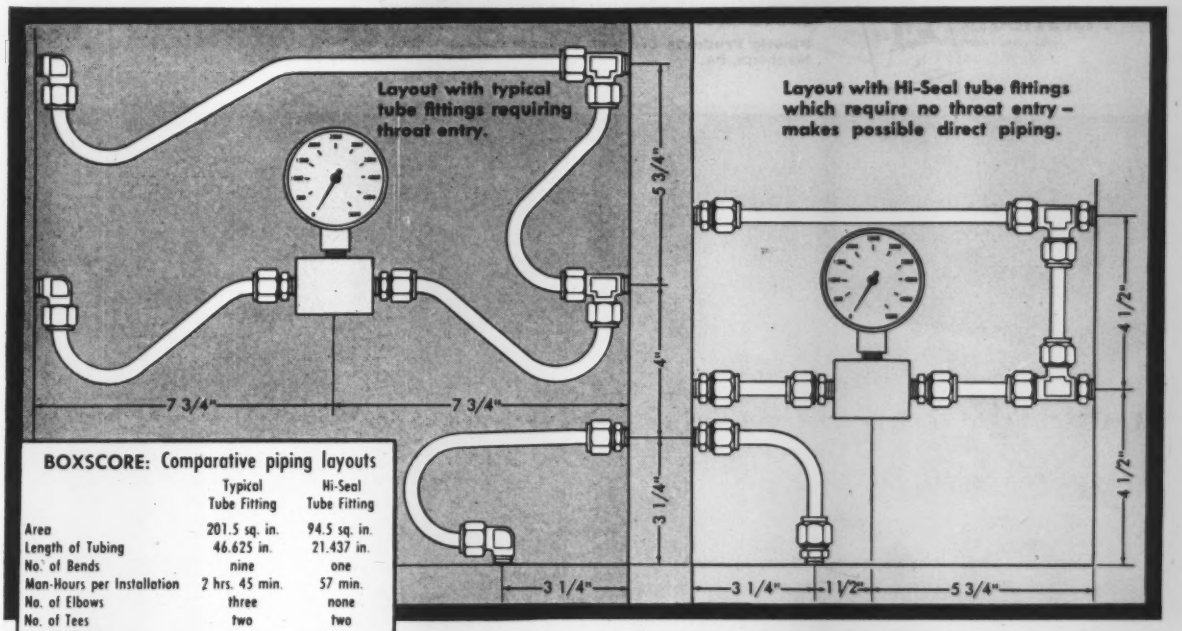
philadelphia gear drives

Offices in all Principal Cities • Virginia Gear & Machine Corp., Lynchburg, Va.

INDUSTRIAL GEARS & SPEED REDUCERS • LIMITORQUE VALVE CONTROLS • FLUID MIXERS • FLEXIBLE COUPLINGS

IMPERIAL *Engineering and Data File*

ENGINEERED TUBE FITTINGS — VALVES — TUBING TOOLS



BOXSCORE: Comparative piping layouts

	Typical Tube Fitting	Hi-Seal Tube Fitting
Area	201.5 sq. in.	94.5 sq. in.
Length of Tubing	46.625 in.	21.437 in.
No. of Bends	nine	one
Man-Hours per Installation	2 hrs. 45 min.	57 min.
No. of Elbows	three	none
No. of Tees	two	two
No. of Straights	three	six

How Hi-Seal saves space—cuts costs

. . . makes possible reductions up to 50% in required piping area . . . up to 66⅔% in installation time!

Imperial Hi-Seal tube fittings open up economical *new piping design concepts* for instrumentation, hydraulic circuits, and other tubing installations. Hi-Seal makes possible far more compact layouts than can be made with conventional fittings — in addition, it brings *new ease and speed* to joint making and utmost reliability.

These design considerations are illustrated in the tubing layouts above. The diagrams show how Hi-Seal actually eliminated nine tube bends . . . saved more than one-half on tubing needed. Total layout area required by Hi-Seal is only 94.5 sq. in., compared to 201.5 sq. in., when an ordinary fitting is used. And 189% *more* manhours were required to tube up the circuit with a typical fitting.

Several key fitting design factors account for Hi-Seal piping economies: (1) Hi-Seal makes a positive butt joint — no need to spring tubing; (2) speedy, foolproof assembly — it is impossible for the fitting to be assembled with the alloy steel sleeve in reverse position; (3) there is no danger of over-torqueing . . . when threads on body of fitting are covered, a pressure-tight seal has been made, a visual assurance of a correct joint; (4) under tests, Hi-Seal fittings have withstood pressure of 4,000 psi at conditions of −320° F. to over 700° F.

with *no* leakage; (5) Hi-Seal fittings can be disconnected and reconnected as often as desired.

Complete line — Hi-Seal fittings are available in brass, steel, stainless steel. Also furnished in Titanium, Tantalum and other metals. Steel fitting supplied with cadmium plate or black phosphate finish. Conform to J.I.C., A.S.M.E. and A.S.A. standards. In sizes for ⅛" to 1½" O.D. tubing. Furnished with Long Dryseal pipe threads or straight thread port seal.

Write for Bulletin No. 3061

IMPERIAL

THE IMPERIAL BRASS MFG. CO.
6300 W. Howard St., Chicago 48, Ill.
In Canada: 18 Hook Ave., Toronto, Ont.

New high-pressure valves assemble directly to tubing — eliminate additional fittings

A revolutionary new line of Imperial needle valves designed for working pressures up to 5,000 psi., and temperatures to 450° F., employs Hi-Seal tubing connections.

Write for Bulletin 3096, or Catalog No. 200

CONTACT YOUR INDUSTRIAL DISTRIBUTOR OR WRITE TO:

THE IMPERIAL BRASS MFG. CO.
Dept. MD-11Y, 6300 W. Howard St.,
Chicago 48, Ill.
Please rush me Bulletins
☐ No. 3061 ☐ No. 3096 ☐ Cat. No. 200

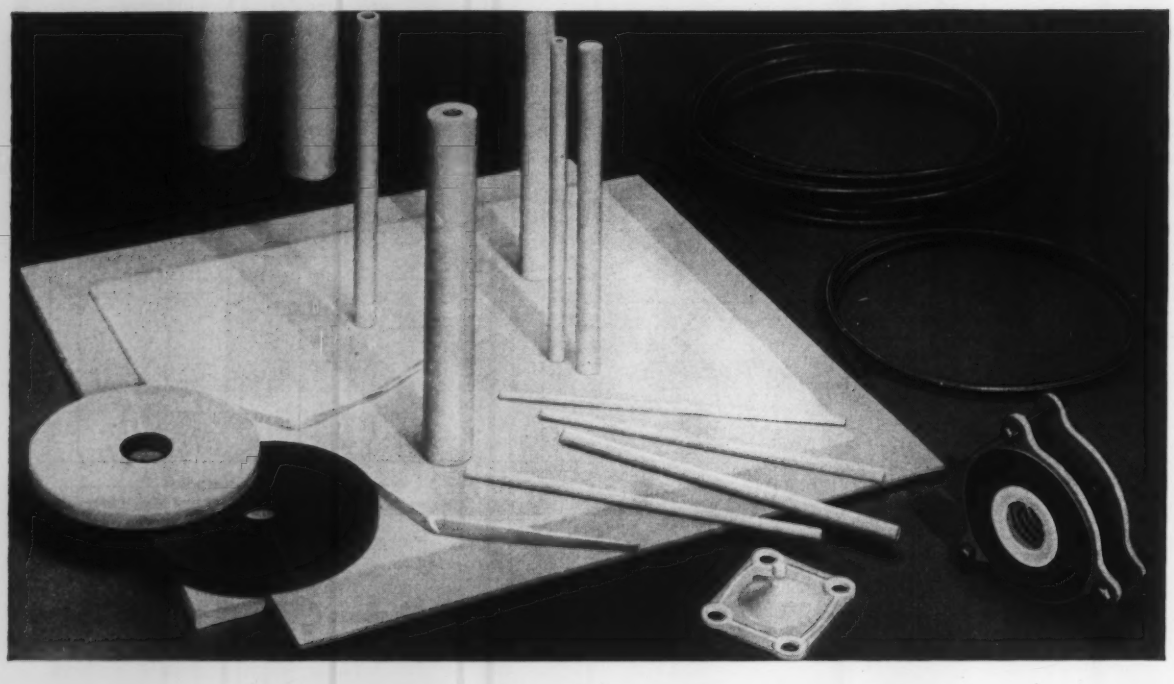
Name .....
Title .....
Company .....
Street .....
City ..... Zone ..... State .....

CUT COSTS, IMPROVE DESIGN AND PERFORMANCE WITH R/M PRODUCTS

PLASTICS

Write for booklet, which provides valuable information on a variety of R/M "Teflon" products.

Plastic Products Division, Raybestos-Manhattan, Inc.
Manheim, Pa.



If you need TEFLON* in any form R/M is the place to get it!

Take advantage of R/M's versatility in "Teflon" fabrication

Raybestos-Manhattan pioneered in research and development in the use of "Teflon." R/M has had vast experience in fabricating this amazing substance . . . has accomplished things with it once thought impossible, such as molding highly complex valve diaphragms.

But R/M has more than the know-how—it has the facilities to produce "Teflon" in exactly the form you want it . . . can supply *all* your needs, from the usual types of tubes, thin-wall tubing, tape, rods, sheets, bondable "Teflon," and flexible wire braid covered hose to complicated molded and machined parts made to your specifications.

That is why R/M should be your headquarters for all your needs in products made of "Teflon," from simple standard types to intricate components painstakingly customized to meet your design requirements. Call on your nearest R/M district office for any assistance you may need. Or write for detailed information.

*A Du Pont trademark

R/M

Brake Blocks, Linings and Clutch Facings

Mechanical Packings and Gaskets

Abrasive and Diamond Wheels

Industrial Drive Belts

Industrial and Automotive Hose

Conveyor Belts

Circle 437 on Page 19↑

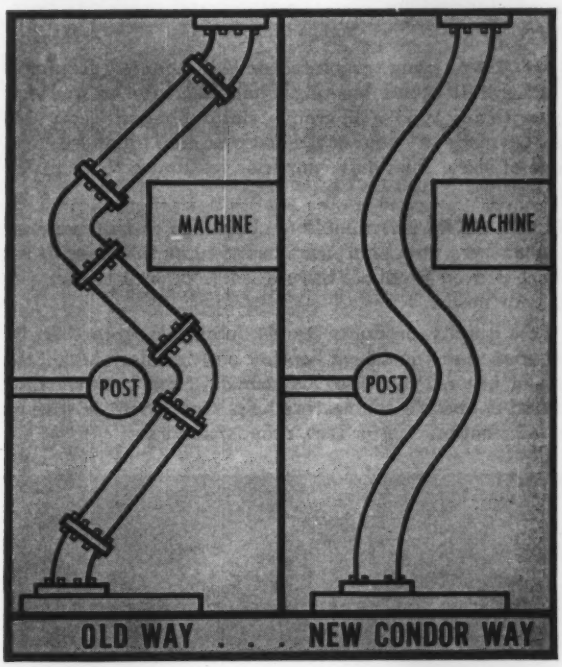
SPECIALISTS IN ASBESTOS, RUBBER, SINTERED METAL, ENGINEERED PLASTICS

RUBBER

Write today for free booklet shown: full details on a wide variety of industrial rubber products.
Manhattan Rubber Division, Raybestos-Manhattan, Inc.
Passaic, N.J.

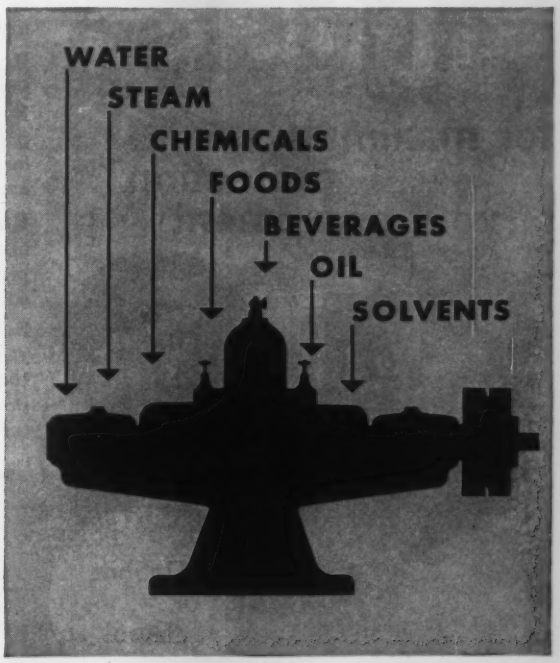
PACKINGS

Write for free booklet giving complete information on R/M Plastic Packings.
Packing Division, Raybestos-Manhattan, Inc.
Passaic, N.J.



Condor Rubber Pipe— tough, light, flexible

Where corrosion, abrasion, vibration or contamination means trouble with iron or steel pipe, versatile Condor Flexible Rubber Pipe is your solution. It actually outlasts other conventional piping in handling coal or coke breeze, ashes, finely broken up materials and many slurries, corrosive liquids and caustic solutions. Whatever the application, Condor Flexible Rubber Pipe goes where you want it to go . . . eliminating fabricated, leaky joints and cumbersome supports. Raybestos-Manhattan also makes to your special order rubber expansion joints, rubber-lined pipe, fittings and process equipment, acid hose, rubber covered rolls. You can depend on R/M also for rubber hose, transmission belt and V-belts, Poly-V drives, conveyor belt, molded and extruded rubber products. Rubber specialists since 1893.



Two R/M Plastic Packings—R/M Universal and R/M "versi-pak"®—answer the designer's problem of lower friction and longer wear

These superlative R/M packings have features that will pay off in every pump and valve you design. Both are custom made for low friction and for maximum resistance to heat, materials handled, and pressure. Locked-in lubrication and soft, open-fiber asbestos combine to reduce wear on rods and valve stems, even after long service.

In Universal Plastic Packing, R/M has combined asbestos fiber and graphite with lubricant and binder. Designed for all types of circulating, reciprocating and centrifugal pumps. Types are also available for oil and for food processing equipment. R/M "versi-pak" is similar in composition, but has a special solvent-proof binder that makes it ideal for solvent installations up to 350 F and 600 psi. Send for complete data for specific recommendations.

RAYBESTOS-MANHATTAN, INC.

FACTORIES: Passaic, N.J. • Bridgeport, Conn. • Manheim, Pa. • Paramount, Calif. • No. Charleston, S.C. Crawfordsville, Ind. • Neenah, Wis. • Peterborough, Ontario, Canada

Rubber Lined and Covered Equipment

Sintered Metal Friction Elements

Asbestos Textiles

Industrial Adhesives

Teflon Tape, Packings, Sheets, Rods, Tubes

Engineered Molded Rubber and Plastics

R/M

If you are in the market for rugged, dependable bushings and bearings at an *economical* price—products that provide maximum protection in almost *any* type of equipment—choose from Johnson's . . .

● *Bronze on Steel* ● *Rolled Bronze* ◯ *Babbitt on Steel*

three musts

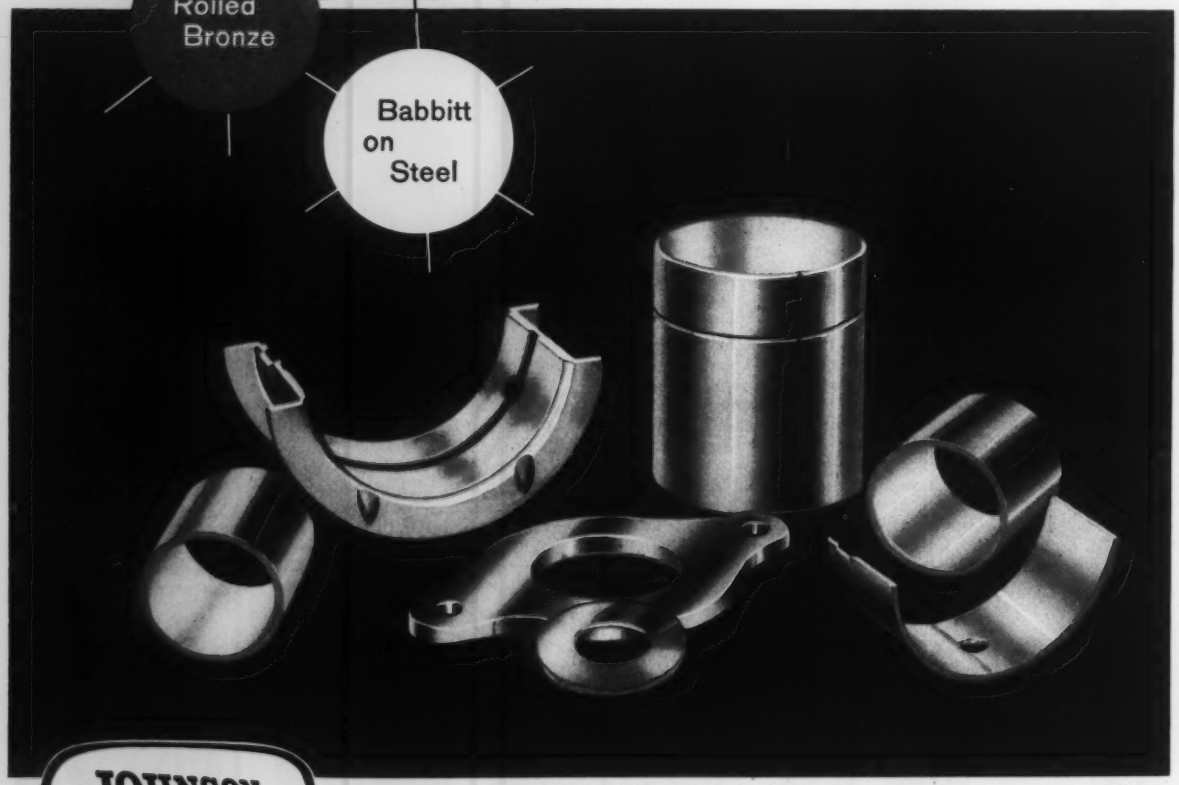
for maximum protection of your equipment

Bronze on steel thin-wall bushings are economical and practical. Plain or flanged half bearings are available also, precision machined to fit your application. This material also can be furnished stamped for plates, washers and other flat bearing surfaces.

Rolled bronze, plain, graphited or ball-indented are available as either full round bushings, half bearings or washers. Furnished with any type of oil groove, slot or hole, these durable parts can be made to your specifications and produced in a large range of sizes. They have superior resistance to corrosion and wear.

Babbitt on steel is available for bushings or half bearings and thrust washers. Precision machined to close tolerance, these performance-proved products have a range of wall thicknesses suited to your needs.

Behind these quality products stands Johnson's more than 50 years' experience in the sleeve bearing and bushing field. Like thousands of others, you, too, can benefit from these quality products and Johnson's engineering help. Call, write or wire us for more information . . . for fast, reliable service.



JOHNSON Bearings

Subsidiary: Apex Bronze Foundry Co., Oakland, Cal.

Johnson Bronze

525 Mill Street, New Castle, Pa.

the neg'ator® sketchbook

The NEG'ATOR® Spring is a new basic mechanical component—a coiled band spring which extends many times its original size without the increasing force common to conventional springs. Used as an extension spring, a motor, band, clamp, or clip, this revolutionary new constant-force component upsets all previous spring principles by doing what springs have never done before.

SIMPLE NEG'ATOR® BANDS REPLACE COSTLY GEARED RACK AND PINION

The NEG'ATOR constant-force spring performs an interesting function in the tester shown in Fig. 1. Here it acts as a "toothless rack" and takes the place of a geared rack and pinion. As a result, the instrument is simpler in construction, operates more smoothly, and sells for considerably less than it would if gears were used.

In construction and operation, this precision-built instrument, called a "carton scorebend tester," functions something like the old "bottle capper" people used to use to cap home-made rootbeer. However, instead of being used to exert a heavy pressure, the tester accurately and sensitively transmits motion for measurement. Designed for quality control work in the paper industry, it measures the force required to open flat, folded paperboard cartons. Since cartons vary in size (as second-hand bottles used to), the gage head must move up or down to compensate for varying carton sizes. Once the gage head is adjusted on the support column, the gage head must be depressed to contact the carton edge and force it open. Force is read on the gage dial.

A geared rack and pinion could have been used to depress the gage head and even to permit height adjustment of the gage head. Instead, much simpler, smoother operating, far less costly NEG'ATOR springs were used as shown in Fig. 2.

A NEG'ATOR spring links the control knob with the gage carriage. Its coil is drum-mounted on the stationary positioning carriage and its extended end is secured to the movable gage carriage. When the control knob is turned, it winds up the extended end of the spring which pulls the gage and its carriage downward as required by the test. Total linear travel required is 2 inches.

Because the "toothless rack" spring is irreversible, a second NEG'ATOR spring is used in opposition to return the gage to the raised position. A third NEG'ATOR

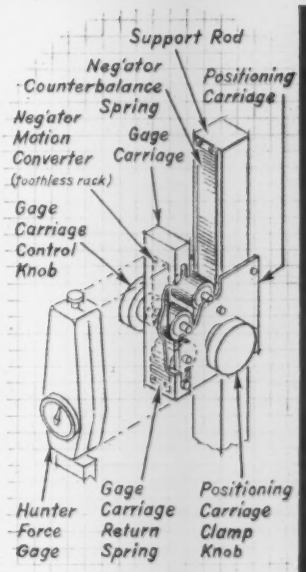


FIG. 2

spring counterbalances the complete gage head on the column support as shown in the drawing. The head is held in position at proper carton height by means of a friction lock knob.

This application was described in more detail in the September 3, 1959 issue of MACHINE DESIGN. Many other eye-opening NEG'ATOR spring applications are described in Bulletin 310N. To learn more about this versatile component, request a copy.

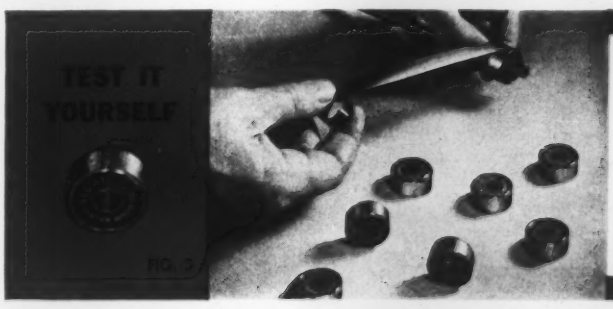


FIG. 3

SAMPLE NEG'ATOR FREE ON REQUEST

Do you want a NEG'ATOR constant-force spring to test for yourself? You can get a 30-inch long, sample spring with a force rating of approximately ½ pound (see Fig. 3) by writing to us at the address below.

PUBLISHED BY HUNTER SPRING COMPANY • LANSDALE, PENNSYLVANIA

A Division of American Machine and Metals, Inc.

For an additional copy of this sketchbook Circle 441 on Page 19

TRANSMIT RECIPROCATING MOTION WITHOUT BACKLASH

Here's some important news for designers of instruments and reciprocating mechanisms.

Using NEG'ATOR spring bands to transmit motion, problems of backlash and slippage can be eliminated simply and at low cost. Unlike gears, motion is smooth and silent. Unlike cords, cables, or chains, NEG'ATOR spring bands stay taut and won't slip.

When pulled out, the spring material resists uncoiling with a constant force and recoils around itself, or a bushing, when released. This tendency to return to a coiled condition keeps it taut.

When both ends are fastened to pulleys as shown in Fig. 4, the NEG'ATOR spring band will transmit motion from one pulley to the other smoothly, silently, and without backlash.

For almost ten years, NEG'ATOR spring bands have been used to transmit motion accurately in various classified defense applications, details of which cannot be reported. Fig. 5, however, shows how NEG'ATOR springs have been applied recently on a commercial product, the new "ROCKET" duplicating machine manufactured by Standard Duplicating Machines Corporation.

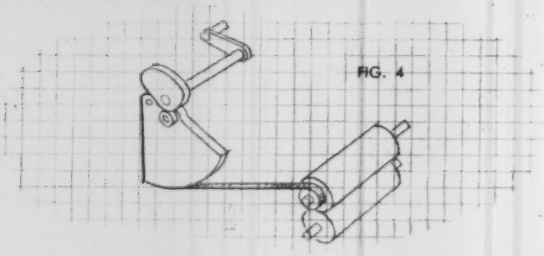


FIG. 4

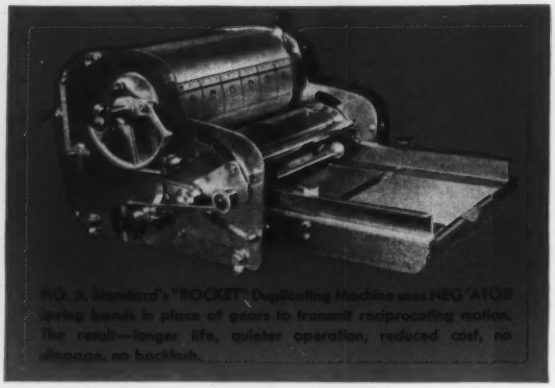


FIG. 5. Standard's "ROCKET" Duplicating Machine uses NEG'ATOR spring bands in place of gears to transmit reciprocating motion. The result—longer life, quieter operation, reduced cost, no slippage, no backlash.

Searching for a gearless method to link and synchronize the action of paper handling rollers to the timing drive assembly on the new machine, design engineers at Standard tried cords, cables, chains—found that NEG'ATOR springs outperformed and outlasted all.

So, as illustrated, they attached the free ends of two NEG'ATORS to the cam-and-lever driven timing segment and the free end of a third NEG'ATOR spring to an idler pulley. The constant tendency of the NEG'ATORS to return to their original coiled condition eliminates backlash. They rewind smoothly on the drive pulleys as the pulleys are returned, under spring tension, to the cycle starting position.

By replacing gear trains with NEG'ATORS, Standard's engineers obtained the accuracy required for maintaining printing register, and efficient operation, longer life, quieter operation, and reduced unit cost. The "ROCKET" is said to be the "quietest machine on the market."

NEG'ATOR PRINTED TAPES ELIMINATE REWIND MECHANISM ON "DATA-DIAL"

FIG. 6. The "Data-Dial" developed by General Communications Co. uses a printed NEG'ATOR tape at its dial and thus eliminates backlash and need for rewind mechanism.

The "Data-Dial" shown in Fig. 6 is a device developed by General Communications Co., Boston, for rapid indication of nomograph-type readings. The scale shown through the window is tailor-made for specific applications which can include calibration and correction tables, wavemeters, attenuators, potentiometers, and other numerical material which can be reduced to nomograph-type scales.

The tape, see Fig. 7, is a special feature of this unit. It is a NEG'ATOR band of spring steel arranged as shown in the drawing. Because the NEG'ATOR tape attempts to wind itself around the wind-up posts at both ends, the tape applies a constant spring load against the sprocket teeth. This tendency keeps the tape taut—eliminates backlash. In addition, this same "wind-up" tendency allows the knob to be turned in either direction without a separate wind-up system which, ordinarily, would be necessary.

The tape is Type 301 stainless steel, selected because it prints well and is reliable under stress.

The "Data-Dial" itself is an interesting and useful device which can be applied in numerous ways by means of a tailor-made scale and rotatable index line which can be made straight, sloped, or curved to fit the application.

Details on NEG'ATOR tapes are available on request to Hunter. General Communications Co. in Boston, Mass., will supply "Data-Dial" information on request.

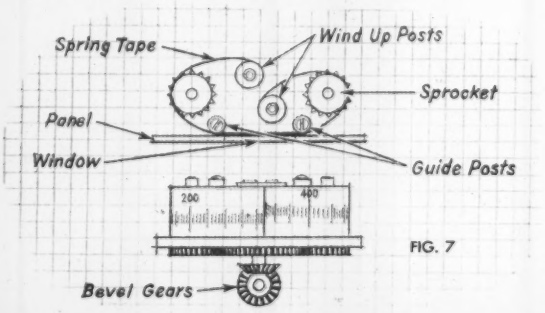
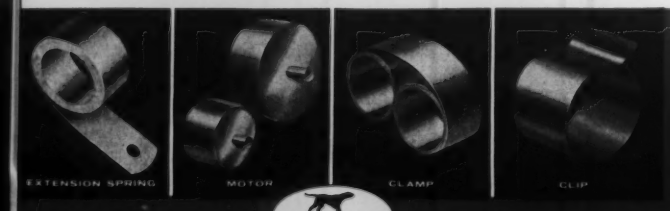


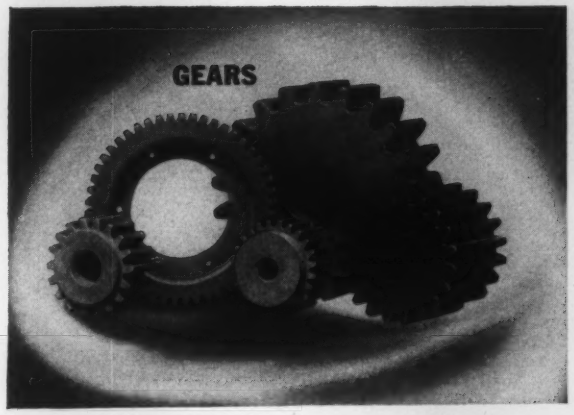
FIG. 7

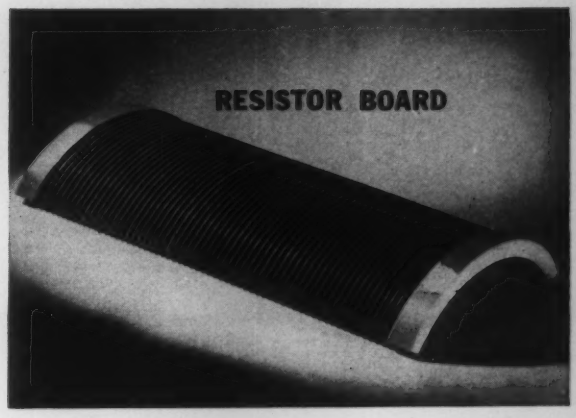


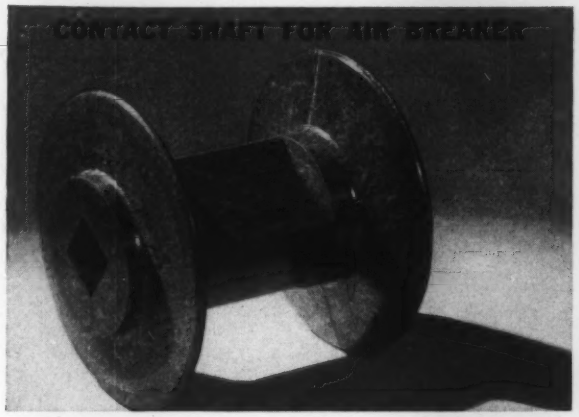
HUNTER

HUNTER SPRING COMPANY
A Division of American Machine and Metals, Inc.
29 Spring Avenue, Lansdale, Pennsylvania
SPRINGS • STAMPINGS • QUALITY CONTROL EQUIPMENT

For an additional copy of this sketchbook Circle 441 on Page 19







Low-cost and with controlled electrical properties. CDF Celoron Molded Plastics are designed for use in electrical and mechanical applications requiring high impact strength with good mechanical and electrical properties.

Close tolerances and high finish with phenolic resin-impregnated CDF CELORON® MOLDED PLASTICS

CDF Celoron Molded Plastics give you all the advantages of low-cost form molding of electrical and mechanical parts. You can even add strength selectively to any section of the item.

Through lower unit costs, CDF Celoron Molded Plastics offer you longer life per dollar invested. Resist water, oil, grease, and many other corrosive solutions and atmospheres. In gears, they operate without continuous lubrication at temperatures of up to 150°F.—300°F. in oil. CDF Celoron Molded Plastics are also sound-absorbent, shock-resistant, and abrasion-resistant.

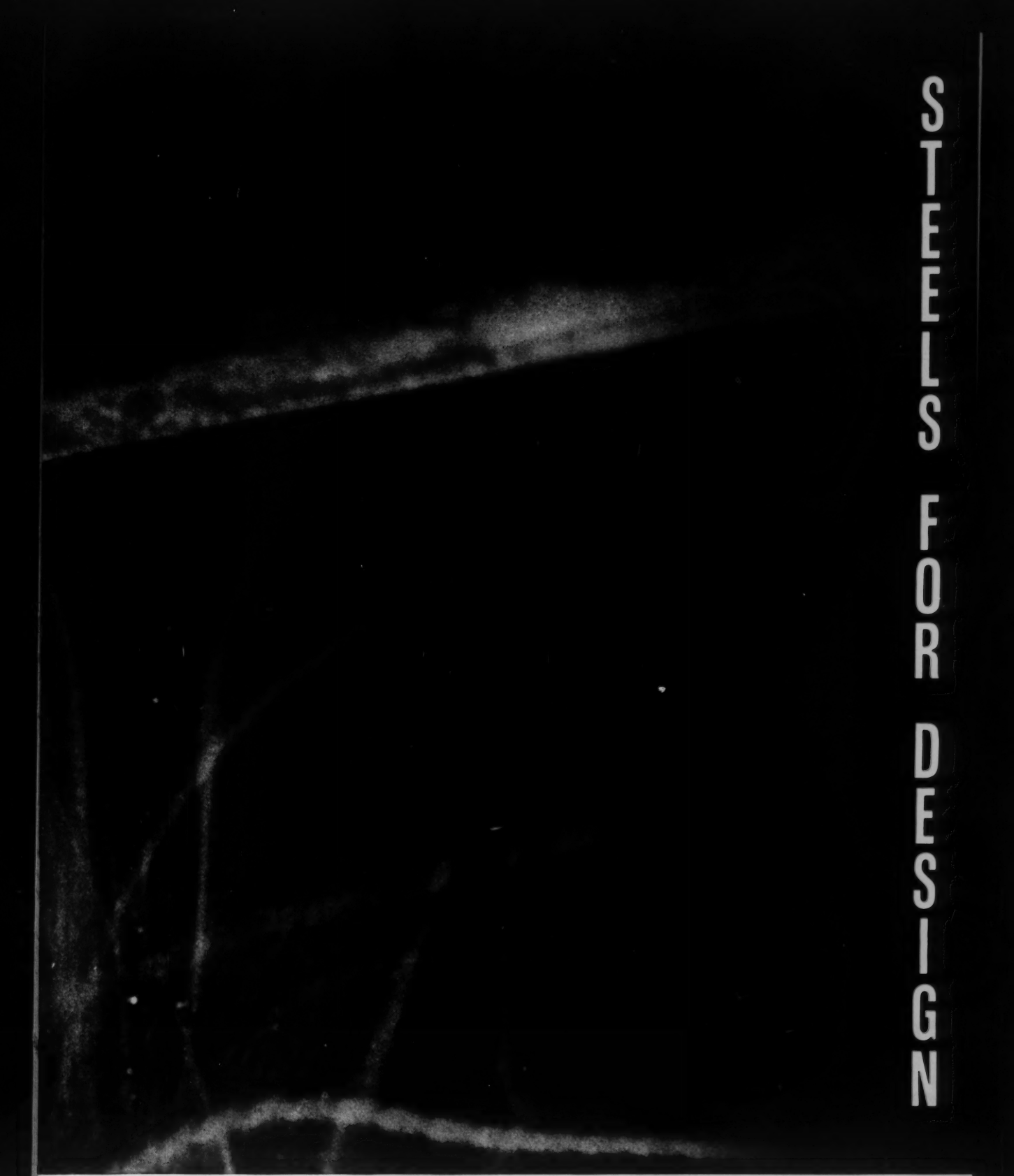
You can save machining time through CDF's custom molding and complete fabrication facilities. You'll also save costs through CDF's mass production of Celoron parts.

See your CDF sales engineer today. He'll show you how CDF Celoron Molded Plastics, plus complete custom molding and fabrication, can save you production time and costs.

CONTINENTAL-DIAMOND FIBRE
A SUBSIDIARY OF THE Bakelite COMPANY, NEWARK 23, DEL.
In Canada: Continental-Diamond Fibre of Canada Ltd., 46 Hollinger Road, Toronto 16, Ont.

Jointly, We've come a long way since man first found that he could unite pieces of metal by

No matter what technique you use, the finished joint is best when the welded material is steel.

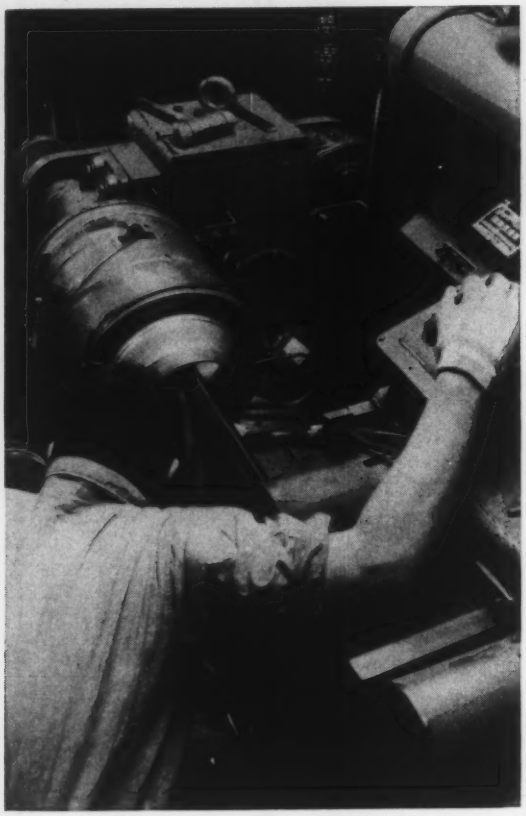


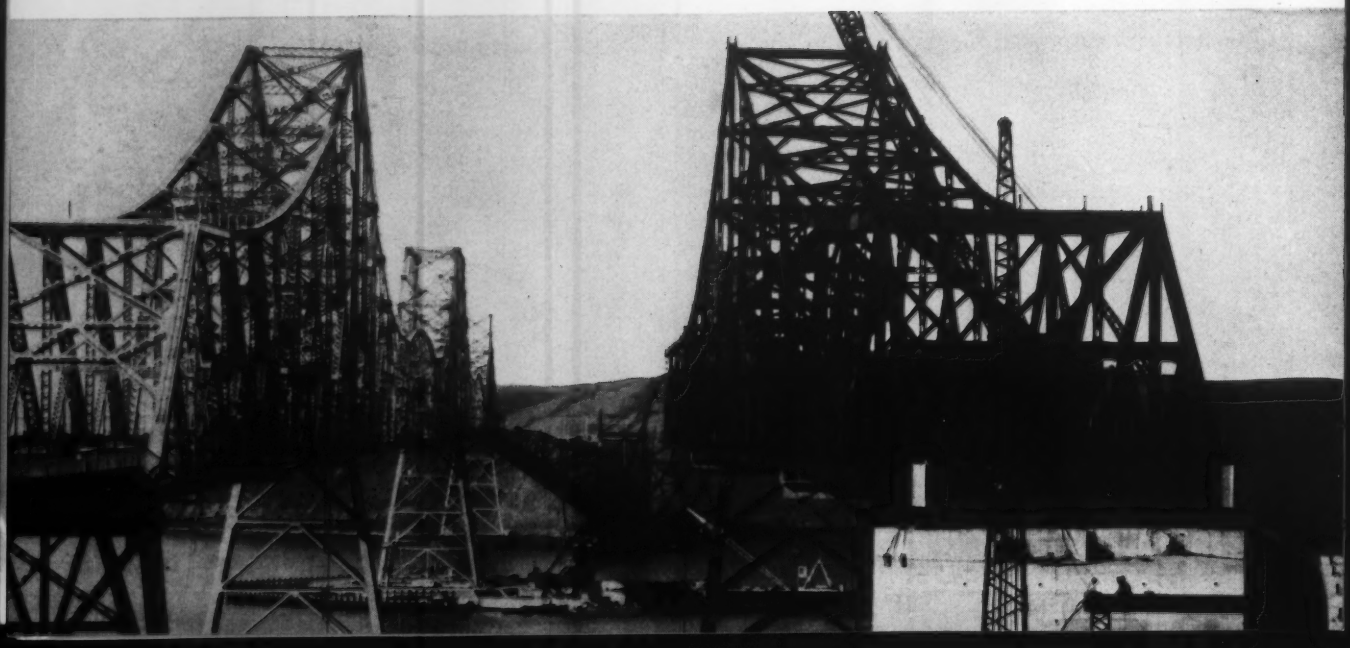
STEELS FOR DESIGN

beating them together while they were hot. Now there are almost 40 different welding techniques.

Above, you see a close-up photograph of arc-welding. For a more complete picture of welding, turn the page. ▷ ▷ ▷

Please direct inquiries to advertiser, mentioning MACHINE DESIGN





STEELS FOR DESIGN

Stainless Steel makes a flawless milk can—Milk cans have to be surgically clean. That's why the John Wood Company makes them from Stainless Steel, with **welded** joints. Here, you see a "Heli-arc" welding machine that was specially designed to weld the inside bottom and outside bottom of the can in one operation. The welding head is retracted to the breast of the can where again, the inside and outside welds are done in one operation. A nipple is gas-welded to the bottom of the can and all the joints are polished to a mirror finish—ready to pass microscopic inspection. Because of the outstanding design and fabrication processes developed by this company, they are now equipped to produce 50% of all the Stainless Steel can requirements for the entire dairy and vending machine industries.

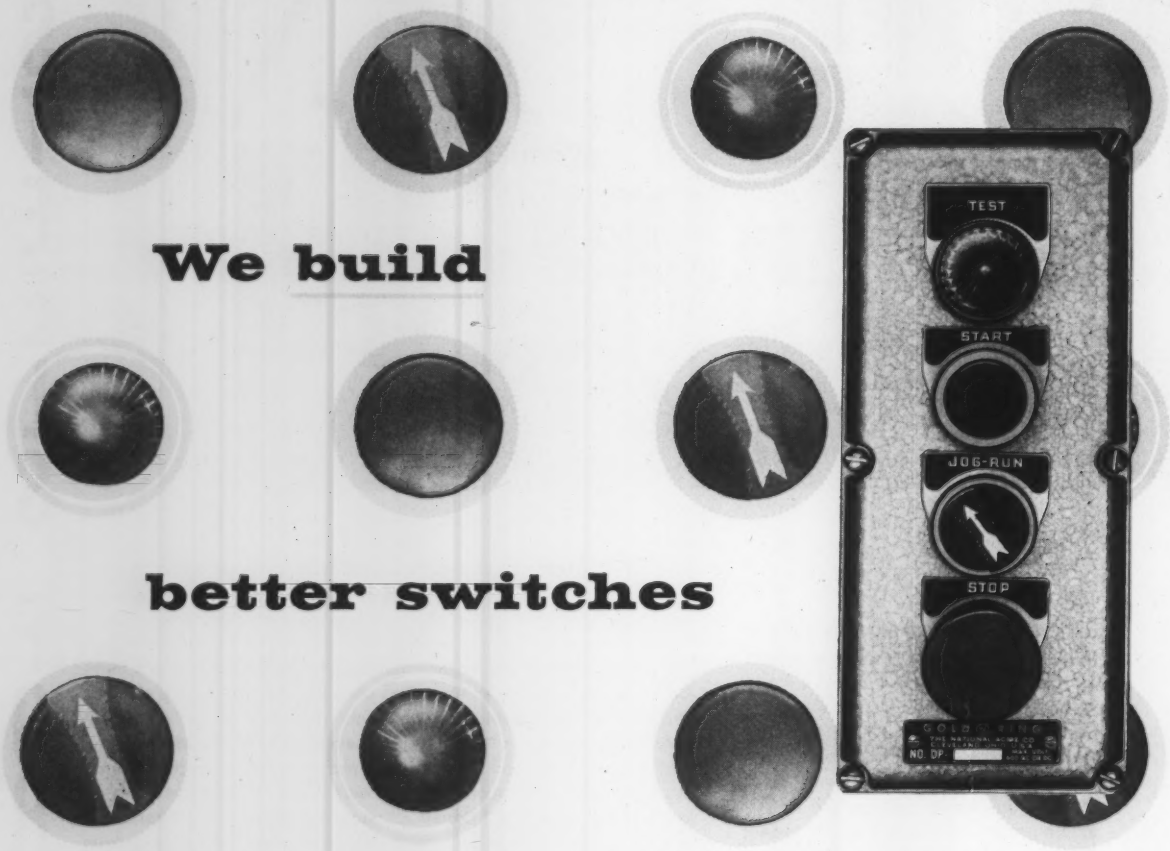
USS "T-1" Steel stops saddle block failure—A saddle block links the dipper stick to the boom of a power shovel (see arrow above) and provides the digging effort. It has to withstand tremendous stress and shock—failures are not uncommon. But one operator had too many saddle block replacements so he asked J. B. Lund's Sons Co. to make a stronger unit. The conventional solid cast steel or forged steel block would have been too vulnerable, so the additional strength had to come from a **welded** assembly of strong steel plates. But the higher carbon content that increases the strength of most types of steel also decreases the weldability. They solved the dilemma with USS "T-1" Constructional Alloy Steel. "T-1" brand is a **low** carbon, quenched and tempered alloy steel with tremendous strength—100,000 psi minimum yield strength. The photo shows the finished block made from "T-1" steel plates that were edge-welded 1¼" deep. This block has never failed.

High Strength Steel cuts dead weight—You can stand beside the Carquinez Strait in California and size-up thirty years advancement in bridge building. There are two spans there, side-by-side; one is 31 years old, the other was completed last year. The builders of the new span saved 2,128 tons of steel because they designed the new Carquinez Strait Bridge with USS TRI-TEN High-Strength Low-Alloy Steel and USS "T-1" Constructional Alloy Steel. With yield strength levels of 46,000 psi min. and 90,000* psi min., respectively, these ultra-strong steels permitted thinner, lighter truss members that were shop-welded instead of riveted. 100% efficiency butt welds saved 20% in the weight of tension members by providing extra material at the holes for the connection bolts. The smooth, rivet-free surfaces are less vulnerable to corrosion . . . save thousands of dollars in maintenance.

USS, "T-1" and TRI-TEN are registered trademarks

United States Steel USS

*Now 100,000 psi for plates up to 2½ inches.



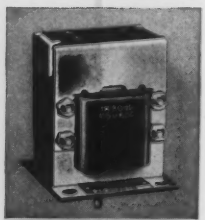
We build better switches because we can't buy them

...IT'S AS SIMPLE AS THAT...AND THEY COST NO MORE THAN OTHER SWITCHES

We had to build Gold-N-Ring Control Switches to meet our own high reliability specifications . . . our reputation was a part of this important fact. We're machine tool builders. We can't afford to be responsible for costly down-time on important capital investment equipment due to inferior control switches. That's why we build them like precise machine tools . . . and why it will pay you to check with us.

A wide range of basic units meets practically every need . . . as well as completely assembled stations in 1 to 4 button sizes to meet your electrical specifications. Ask our representative to call, or send for Bulletin ECS-56 . . . the complete selection and ordering guide.

LIMIT SWITCHES. A full line, originally designed for machine tool applications but now used wherever the highest reliability factors are required. Bulletin EM-51.



SOLENOIDS. A full line of standard and custom units for AC or DC. Push or pull types with capacities up to 25 lbs. Bulletin EM-52A.

ELECTRICAL MANUFACTURING DIVISION

National Acme

THE NATIONAL
ACME COMPANY
188 E. 131st STREET
CLEVELAND 8, OHIO

Circle 443 on Page 19

NICKELOID METALS IN A *Woman's World*

Part of that happy gleam in the eyes of a modern homemaker is because of the convenience, the ease, and the pleasant decorative warmth of her kitchen. Along with the soft woods and pleasant colors she revels in the easy-to-maintain gleam of clean bright appliances, housewares, working surfaces and decorative trim. The efficient chromium and the warm copper . . . seen so much about the modern kitchen . . . are most probably stamped or fabricated from one of the versatile galaxy of Nickeloid Metals. There's eye appeal and there's sales appeal in appliances and housewares which utilize Nickeloid Metals. Liked, too, by designers and production engineers. Complete information about Nickeloid Metals and the Nickeloid pre-finished metals method is contained in a special kit, which will be mailed you on request.

NICKELOID METALS
SINCE 1898
NM

AMERICAN NICKELOID COMPANY, PERU 8, ILLINOIS Plants: Peru, Ill., and Walnutport, Pa.

Circle 444 on Page 19

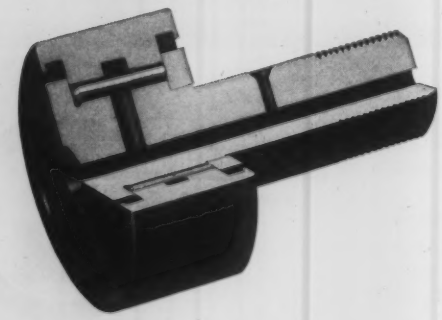
only McGILL® sealed *CAMROL*® cam followers give you . . .

effective sealing

prelubrication

high radial and shock capacity

in a full range of sizes



Effective sealing of the CAMROL cam follower against moisture, dirt, chips, etc. guarantees longer service life . . . reduces maintenance. This sealed construction retains lubricant and eliminates need for frequent relubrication, so often undesirable in cam action, guide support and track roller applications.

Special seals are built in at stud and flange ends. A black oxide finish on all exposed surfaces offers outside corrosion resistance. The channeled reservoir above the rollers in the outer raceway bore helps store reserve lubricant, sufficient in most cases for lifetime service. Relubrication is possible through convenient oil holes. The new SCF sealed CAMROL cam followers interchange with proven standard CAMROL cam followers. Standard stock with roll diameters up to 4" are available for both stud and shaft mounting.

For maximum bearing life where contamination is a problem, specify sealed CAMROL cam followers. Ask your McGill representative or our engineering department for recommendations.

Write for Catalog No. 52-A

engineered electrical products

McGILL®

precision needle roller bearings

McGILL MANUFACTURING COMPANY, INC., BEARING DIV., 200 N. LAFAYETTE ST., VALPARAISO, INDIANA

Circle 445 on Page 19

Circle 446 on Page 19→

KEYSTONE and Yellow Strand®

working together for 30 years to maintain wire rope leadership —

For more than three decades, Keystone has worked closely with Broderick & Bascom Rope Co., St. Louis, Mo., to produce superior quality wire that meets the ever-changing demands of the wire rope industry.

A good example is the large 3⅛" Yellow Strand "Powersteel" Dragline Rope with a breaking strength of 448 tons. This strong, abrasion-resistant, high-carbon steel wire rope was developed to match the increased capacity, power and speed of today's giant draglines and strip mining equipment.

Sharply contrasting to the big rope is the 1/32", 1 x 7 Galvanized Aircraft Strand—also illustrated—one of the smallest B & B wire ropes.

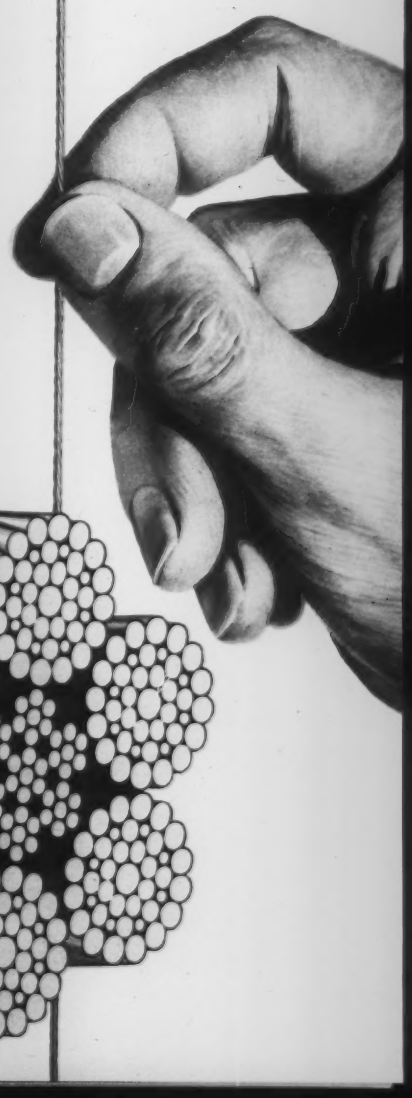
Keystone and B & B engineers together have developed unusual manufacturing methods to produce a wire rope with superior performance.

You, too, can enjoy these sales advantages and create customer demand by specifying Keystone Wire wherever wire is used in your products. Call your Keystone representative!

Keystone Steel & Wire Company, Peoria 7, Illinois

KEYSTONE
WIRE FOR INDUSTRY

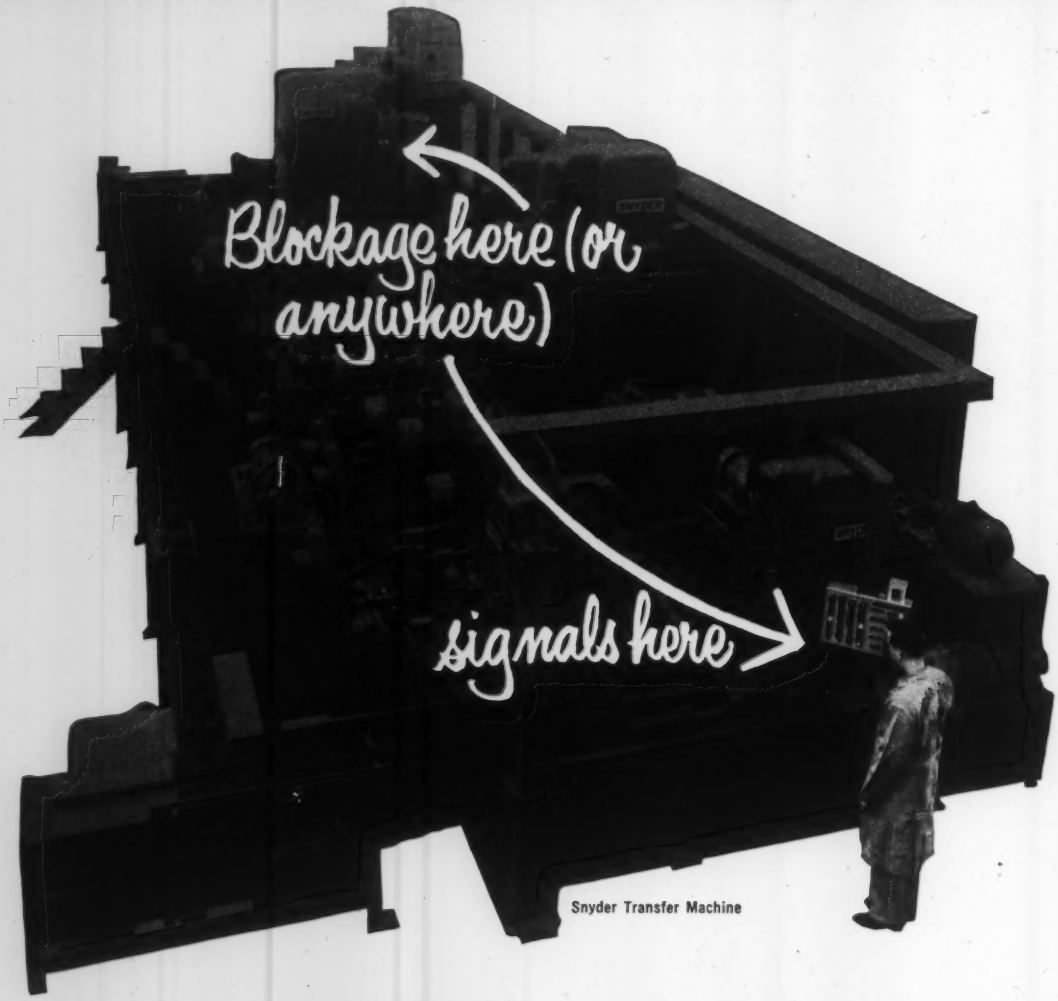
The large wire rope consists of 295 individual wires, laid up into 6 strands of 41 wires each with Independent Wire Rope Core. The small, galvanized aircraft strand is made up of 7 wires.



KEYSTONE ROPE WIRE WIRE STUDY

TRABON®

CENTRALIZED LUBRICATING SYSTEMS



Snyder Transfer Machine

First with Central Warning in a Centralized System!

Yes, Trabon's positive piston operation gives you a truly centralized oil or grease system — making sure that every bearing gets its accurate measured amount — **and giving you central warning** at the pump or control panel when a bearing is blocked **anywhere** in the system.

For example, on this 60 foot transfer machine a red fault light located at the operator's station gives immediate warning in case of blockage 10 feet or 60 feet away. There is no need to make tedious, time-wasting inspection trips at frequent intervals to make sure all bearings are getting a positive shot of lubricant. Trabon does the job for you! And—should blockage occur—finding the trouble spot is easy! For Trabon's inexpensive Reset Indicators enable you to pinpoint the blocked condition in a matter of seconds.

Why not specify Trabon for your machinery investment. It's the modern, better way to lubricate positively and safely! (And versatile Trabon systems can be operated automatically by air, hydraulic, electric or mechanical actuation.)

"Centralized" OIL AND GREASE SYSTEMS "Meterflo" CIRCULATING OIL SYSTEMS

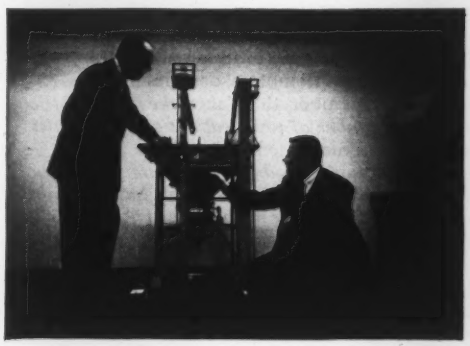
Trabon Engineering Corporation 28769 Aurora Road • Solon, Ohio

Circle 447 on Page 19

Bill St. John (left) with Heltzel Chief Engineer, W. J. Kirchner, who said: "As a result of Bill's recommendation, we're using Jeffrey's combination chain. It's economical, yet gives the needed strength in our higher elevators."

"Jeffrey gives us the kind of service we want"

Heltzel buyer, John Holodnak (right): "It's strictly service as far as Jeffrey is concerned with us. Jeffrey gives us quotations in two days or less. They stock for us. Delivery is no problem."



The Heltzel Steel Form & Iron Company, of Warren, Ohio, manufacturer of concrete batching plants, now looks to Jeffrey for power transmission components. Heltzel engineers and buyers agree that Jeffrey gives them the kind of service they want.

Commenting on Jeffrey service, Heltzel Chief Engineer, W. J. Kirchner stated, "Originally, Jeffrey's Director of Research came to Heltzel with Bill St. John (Jeffrey Northeast Ohio Sales Engineer). They sat down and discussed our needs – Bill knows what he's talking about. We understand each other. We have followed his recommendations in many instances."

Find out exactly how Jeffrey delivers the kind of service you ought to have. Arrange a meeting through the Jeffrey office nearest you, or contact: Manager, OEM Sales, The Jeffrey Manufacturing Company, 798 North Fourth Street, Columbus 16, Ohio.

JEFFREY

CONVEYING • PROCESSING • MINING EQUIPMENT...TRANSMISSION MACHINERY...CONTRACT MANUFACTURING

Circle 448 on Page 19

NOW...
Robbins & Myers Calculates a New Motor Design EVERY 1 to 6 MINUTES!

R&M Engineers Explore Hundreds of Design Combinations to Achieve OPTIMUM MOTOR PERFORMANCE!

How many ways *could* a motor be designed — a polyphase motor, for example? At least 27 basic variables offer 27^{27} (30 zeros) possibilities! Theory, of course, but still there's a colossal number even after obviously impractical designs are ignored. Working with slide rule, an engineer can calculate maybe four designs per day . . . and that's the time-consuming way it was done once. But now ROBBINS & MYERS engineers can explore hundreds of design possibilities, using their Data Processing System. With infallible accuracy, IBM's 20,000 digit "Magnetic Memory" is able to calculate a new motor design every one to six minutes! Because R&M engineers can now explore hundreds of design combinations before they make a final decision, you get the one motor that will deliver optimum on-the-job performance! And at no extra cost!

"Mechanized" mathematics at ROBBINS & MYERS also gives engineers more time for design *vision* and *decision*, which no machine can possibly provide . . . and enables them to improve existing motors by probing alternate design possibilities.

If you are ordering integral or fractional HP motors, or series motor parts, remember this fact: *the greater the number of practical design possibilities the manufacturer explores before the motor is produced, the better the motor will perform!* When your motor comes off the assembly line at ROBBINS & MYERS, you can be certain you are getting the best design possible, perfectly adapted to your requirements, and quality-built to perform dependably for years to come!

ROBBINS & MYERS, INC.

motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps

SPRINGFIELD, OHIO · BRANTFORD, ONTARIO

Circle 449 on Page 19

MOTORS

1/200 thru 200 horsepower

Design answers in seconds from IBM 20,000 digit magnetic memory!

Integral Motors (left), range from 1 to 200 HP in single-phase, direct current, polyphase, totally-enclosed fan-cooled, and explosion-proof types.

Standard Fractional HP Motors (right), are available in polyphase induction, capacitor start, resistance split-phase, and permanent split capacitor, in open and totally-enclosed types.

Precision-Made Universal Motors and Series Motor Parts (left), enable manufacturers of electric power-driven equipment to make the motor an integral part of their product.

Business Machine and Commercial Appliance Motors (right), are available in standard or custom designs.

WHO SAYS

there's nothing new in Socket Set Screws!

The revolutionary P-K W-POINT Socket Set Screw is not only new—completely new—it is capable of delivering the highest degree of holding power ever attained... at no increase in price!

What's the difference between the new P-K W-Point and ordinary cup point set screws? It's the new pivot point that's built into the cup! This exclusive P-K feature reduces "wobble" caused by the required tolerance clearances between screw threads and the tapped hole . . . minimizes "tipping" motion imparted by key tightening . . . creates tracking which is uniformly even in depth and shape . . . results in frictional engagement of both cup edge flanks . . . provides:

30% more back-out torque

50% more resistance to vibration

50% more resistance to rotary slippage

Test this new socket set screw in your own plant. Ask your P-K Industrial Distributor for complete information and samples today, or write to P-K direct for technical bulletin No. 1106.

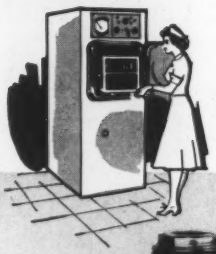
PARKER-KALON® W-POINT Socket Set Screw

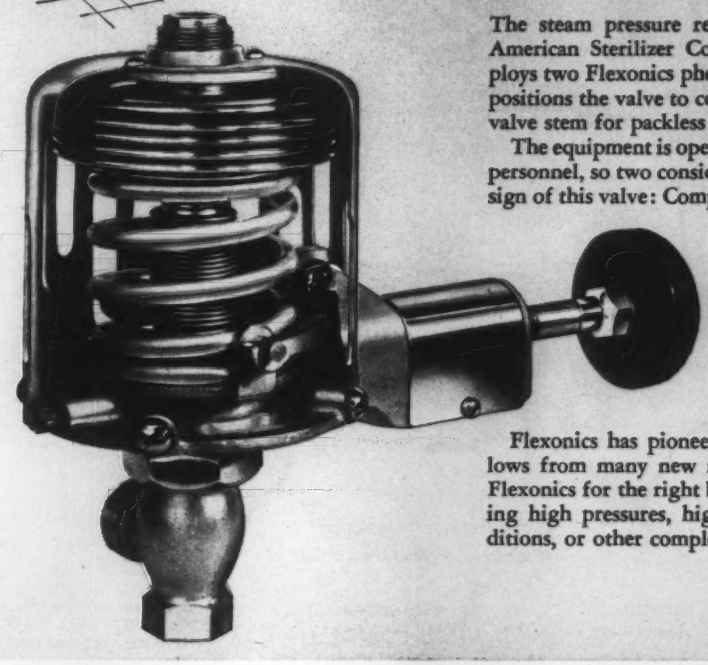
PATENT PENDING

PARKER-KALON, *a division of General American Transportation Corporation. Clifton, New Jersey. Offices and Warehouses in Chicago, Los Angeles.*

Reliability is all-important...

AMERICAN STERILIZER SELECTS **Flexonics** BELLOWS





The steam pressure regulator that governs the operation of American Sterilizer Company's surgical supply sterilizers employs two Flexonics phosphor bronze bellows in vital spots. One positions the valve to control steam pressure; the other seals the valve stem for packless construction.

The equipment is operated by nurses and other non-mechanical personnel, so two considerations outweighed all others in the design of this valve: Complete safety, with zero maintenance, practically forever. These demands had to be met in the face of such design problems as elevated pressure and temperature, possible corrosive conditions, and providing sufficient travel for close control over a wide turndown. After exhaustive tests, Flexonics bellows are now standard on all Amsco sterilizers and autoclaves.

Flexonics has pioneered the design and manufacture of bellows from many new materials including Hastelloy. Come to Flexonics for the right bellows design in any application involving high pressures, high temperatures, extreme corrosive conditions, or other complex problems.

Flexonics temperature sensor gives automatic top-burner cooking ... and slashes original cost

For use in either gas or electric ranges, this top burner control, designed and manufactured by Flexonics for one of the country's leading range manufacturers, allows them to offer automatic top-burner cooking at less than half the cost of previous devices used for this application. Installation costs, too, are greatly reduced. Temperature sensing head and fluid reservoir are one small, rigid assembly, connected by capillary tube to the Flexonics metallic diaphragm that operates the modulating gas valve or electric switch. Flexonics design and production abilities can be turned to your own needs—usually with the twin results of improved functioning and lowered costs.

Flexonics Bellows are the simple, straightforward answer to many touchy design problems. For pressure or temperature measurement . . . shaft sealing . . . even low-torque rotary motion . . . call on your Flexonics Bellows expert. Or write for the Flexonics Bellows Design Guide, 20 pages of useful information.

B-810

TOMORROW'S ENGINEERING TODAY

Flexonics
BELLOWS

FLEXONICS CORPORATION • 1339 SOUTH THIRD AVENUE • MAYWOOD, ILLINOIS

Divisions

INDUSTRIAL HOSE • EXPANSION JOINT • BELLOWS • AERONAUTICAL • AUTOMOTIVE

Flexonics Research Laboratories, Elgin, Illinois

In Canada: Flexonics Corporation of Canada, Limited, Brampton, Ontario

Circle 451 on Page 19

NOW! EMCOR® quality standard cabinets serving you coast to coast with nationwide representation

EMCOR Factory-trained Sales Engineering Representatives are as near as your phone. These qualified men can help you with your enclosure problems thru sound engineering "know-how." Contact the EMCOR Representative nearest you for specific details.

NORTHWESTERN:

N. R. SCHULTZ COMPANY

***Seattle Office:**
4227 Airport Way
Seattle, Washington
Telephone: MAin 4-8650

WEST COAST:

J. C. VAN GROOS COMPANY

***Los Angeles Office:**
21051 Costanso Street
P.O. Box 425
Woodland Hills, California
Telephone: Diamond 0-3131
TWX: Canoga Park, Cal. 7034

***San Francisco Office:**
1178 Los Altos Avenue
Los Altos, California
Telephone: WHitecliff 8-7266

TEXAS, OKLAHOMA, ARKANSAS:

EDWARD F. AYMOND CO.

***Dallas Office:**
4312 Maple Avenue
P.O. Box 6595
Dallas 19, Texas
Telephone: LAkeside 6-5233
TWX: DL 206

SOUTHEASTERN:

W. A. BROWN & ASSOCIATES, INC.

***Indian River City Office:**
201 Capron Road
P.O. Box 286
Indian River City, Florida
Telephone: AMherst 7-0411
Titusville, Florida

***Huntsville Office:**
3405 Lookout Drive, S.E.
Mount Sano
Huntsville, Alabama
Telephone: JEfferson 6-8393

***Orlando Office:**
711 North Magnolia
Orlando, Florida
Telephone: GArden 5-5682

***Washington, D.C. Office:**
3610 Mount Vernon Avenue
P.O. Box 5007
George Washington Substation
Alexandria, Virginia
Telephone: TEmple 6-1800

***Winston-Salem Office:**
1707 Princeton
Winston-Salem, North Carolina
Telephone: PArk 5-5384

MIDWEST:

HUGH W. MARSLAND CO.

***Chicago Office:**
6699 Lincoln Avenue
Chicago 45, Illinois
Phone: ORchard 6-1100 & 6-1101

***Indianapolis Office:**
6730 East 19th Street
Indianapolis 19, Indiana
Telephone: FLeetwood 6-4249

WISCONSIN, MINNESOTA, NORTH and SOUTH DAKOTA:

IRVIN I. AARON & ASSOCIATES

***Milwaukee Office:**
829 North Marshall Street
Milwaukee 2, Wisconsin
Telephone: BRoadway 6-8515

***Minneapolis Office:**
614 East Grant Street
Minneapolis 4, Minnesota
Phone: FEderal 6-6659, 6-6650

MICHIGAN, OHIO, WESTERN PENNSYLVANIA:

S. STERLING COMPANY

***Detroit Office:**
15310 West McNichols Road
Detroit 35, Michigan
Telephone: BRoadway 3-2900
TWX: DE 1141

***Cleveland Office:**
5827 Mayfield Road
Cleveland 24, Ohio
Telephone: Hillcrest 2-8080
TWX: CV 372

***Dayton Office:**
363 West First Street
Dayton 2, Ohio
Telephone: BAldwin 8-8794

***Pittsburgh Office:**
4024 Clairton Boulevard
Pittsburgh 27, Pennsylvania
Telephone: TUxedo 4-5515

METROPOLITAN NEW YORK CITY, NEW JERSEY and EASTERN PENNSYLVANIA:

KENNETH E. HUGHES COMPANY

***New York City Office:**
4808 Bergenline Avenue
Union City, New Jersey
Telephone: UNion 7-3204
TWX: UN CY NJ 797
New York Telephone:
OXford 5-0082

***Philadelphia Office:**
101 North 33rd Street
Philadelphia 4, Pennsylvania
Telephone: EVergreen 6-3130
TWX: PH 1012

NEW ENGLAND STATES and UPPER NEW YORK STATE:

TECHNICAL INSTRUMENTS, INC.

***Boston Office:**
90 Main Street
Reading, Massachusetts
Telephone: REading 2-3930
TWX: Reading Mass. 700

***Bridgeport, Connecticut Office:**
1115 Main Street
Bridgeport, Connecticut
Telephone: FOrest 8-4582

***Syracuse Office:**
916 Liverpool Road
Liverpool, New York
Telephone: GRanite 1-7870

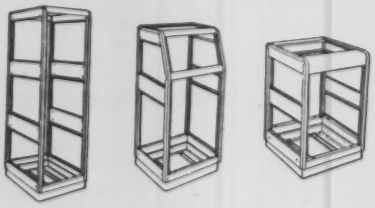
ROCKY MOUNTAIN AREA:

HYTRONIC MEASUREMENTS, INC.

***Denver Office:**
1295 South Bannock Street
Denver 23, Colorado
Telephone: PEarl 3-3701
TWX: DN 863

***Albuquerque Office:**
211 Sierra, S.E.
Box 8394
Albuquerque, New Mexico
Telephone: ALpine 5-0669
TWX: AQ 193

***Salt Lake City Office:**
2022 South Main Street
Salt Lake City, Utah
Telephone: INgersoll 6-4924
TWX: SU 563



WRITE YOUR LOCAL REPRESENTATIVE FOR CONDENSED CATALOG 106

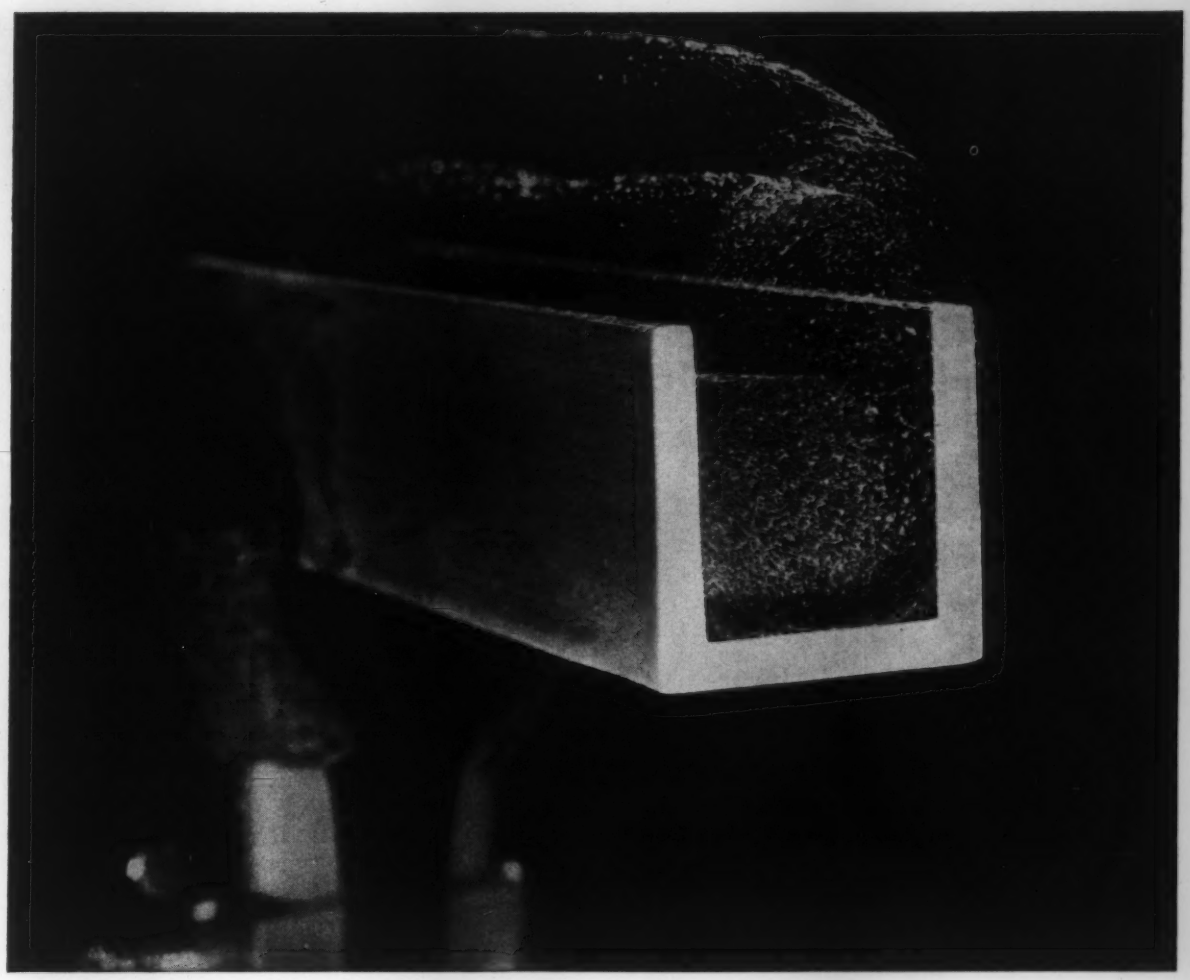
Originators of the Modular Enclosure System

ELGIN METALFORMERS CORP.

630 CONGDON, DEPT. 1226 • ELGIN, ILLINOIS

*Registered Trademark of Elgin Metalformers Corporation

Circle 452 on Page 19



Seal even irregular gaps and seams with

3M HEAT EXPANDABLE SEALERS

TIGHTER, TIGHTER, TIGHTER grow seals of unique 3M Heat Expandable Sealers. Expanding up to 125% under the normal heat of a paint-baking cycle, they cure to a tough, flexible mass that *really* keeps out dirt, water and weather . . . that *completely* seals even the most irregular gap or seam.

In either *liquid* or *extruded bead* form, 3M Heat Expandable Sealers help you save time and cut costs, too. Simply flow in the liquid or lay in the extruded solid by hand. There's no material waste, no cleanup time involved. And because no solvent is present, there's no danger of toxicity or fire.

The unexpanded solid is also efficient as a gasket replacement sealer, flange sealer and for other sealing jobs. It's tacky enough to stay in a vertical or overhead seam. Yet, it can be easily removed. Proper positioning is never a problem. Investigate versatile 3M Heat Expandable Sealers now.

SEE WHAT 3M ADHESIVES CAN DO FOR YOU!

Contact your 3M Field Engineer. Or, for more information, write on your company letterhead, stating your area of interest, to: A.C.&S. Division, 3M, Dept. SAR119, St. Paul 6, Minnesota.

ADHESIVES, COATINGS AND SEALERS DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

Steel Garage Door Made of Republic Electro Paintlok is Backed by Exclusive 5-Year Warranty!

"Berry Doors are guaranteed free of defects in material and workmanship. This warranty covers all parts and components for five full years after original installation."

This is the actual warranty offered by Berry Door Corporation, Birmingham, Michigan — a guarantee that is *exclusive* in the steel garage door industry.

How can the Berry Door Corporation back up its products so unequivocally? One reason is the fact that they are fabricated from Republic Electro Paintlok Steel Sheets!

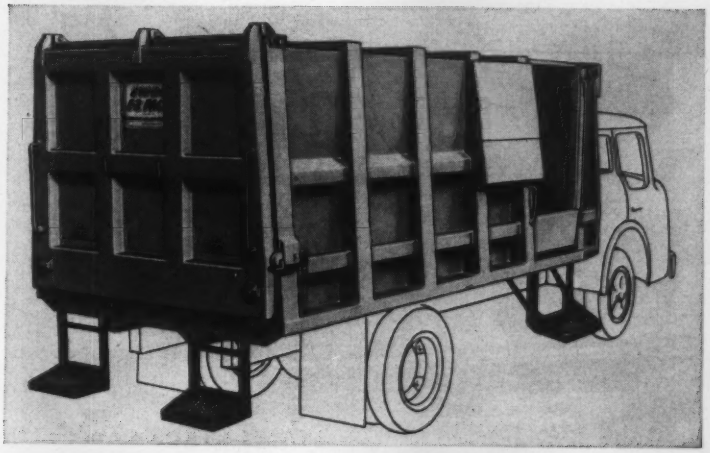
Electro Paintlok Sheets are strong and rigid—only steel itself provides the *strength* of steel. A pure, uniform coating of zinc, applied by electro-galvanizing, provides extra resistance to corrosion, even if the surface of a Berry Door should be scratched or abraded.

After the zinc is applied, Republic Electro Paintlok Sheets are treated chemically, giving them an inert, finely crystalline, non-metallic phosphate coating which is integral with the zinc, and absorbent in character. When a good grade of paint is applied, this coating grips the paint with thousands of tiny teeth that never let go—provides greater durability and beauty for steel doors or other products fabricated of Republic Electro Paintlok.

In addition to these customer benefits (which make products more salable), Electro Paintlok provides a number of important advantages for the manufacturer. It may be stored for extended periods, under approved warehousing conditions, without loss caused by rusting. It increases die life, and permits faster fabrication, with correspondingly lower production costs.

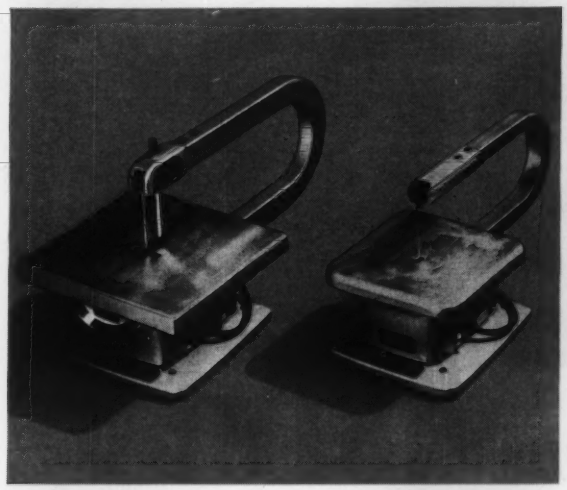
For additional details on Republic Electro Paintlok Steel Sheets, and the advantages they can bring to your particular application, contact your Republic representative now. Or mail the convenient coupon at far right.

Circle 454 on Page 19↑



REPUBLIC HIGH STRENGTH STEEL SOLVES WEIGHT PROBLEMS in *Hydro E-Z Pack* enclosed truck bodies, manufactured by Hercules Galion Products, Inc., Galion, Ohio, for haulers of refuse and garbage. Weight savings made possible by strong, tough, Republic "50" High Strength Steel allow *E-Z Pack* unit to be carried on a chassis as small as that of a two-ton truck. Reduced weight also permits increased payload—fewer trips to the dump. At the same time, High Strength Steel stands up easily under heavy compressive force of packer blade and allows tight compaction of loaded materials. High resistance to the corrosive action of refuse, as well as to the abrasive effects of cans, crates, tree limbs, and other materials, assures long, dependable service. Find out how Republic High Strength Steels can pay off in your application. Mail coupon for further information.

Circle 455 on Page 19↑



SAVINGS FACTS ABOUT REPUBLIC ELECTRUNITE® MECHANICAL TUBING. By using ELECTRUNITE Mechanical Tubing in the manufacture of jigsaws, Syncro Corporation saved time, materials, and costs on production of the blade-yoke. Square tubing was recommended for one model, rectangular tubing for the other. Results: reduction in weight of the blade-yoke, improved product appearance, savings in time, materials, assembly, and shipping costs. Contact your Republic representative, or mail coupon for more facts on ELECTRUNITE.

Circle 456 on Page 19↑

REPUBLIC'S NEW HIGH STRENGTH POWDER, TYPE HS6460, opens the way to new markets for new applications using sinterings for highly stressed parts. Type HS6460 can be used with existing operating equipment. It provides a minimum tensile strength of 60,000 psi at 6.4 density as sintered, and 100,000 psi heat treated. Type HS6460 maintains its dimensional characteristics after sintering—less than .004 inches per inch shrinkage from die size at 6.4 density. Available in production quantities up to and including 12 tons, or in multiples thereof. Mail coupon.

Circle 457 on Page 19↑

REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

REPUBLIC STEEL CORPORATION
DEPT.MD-8136-A
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

Please send additional information on the following:

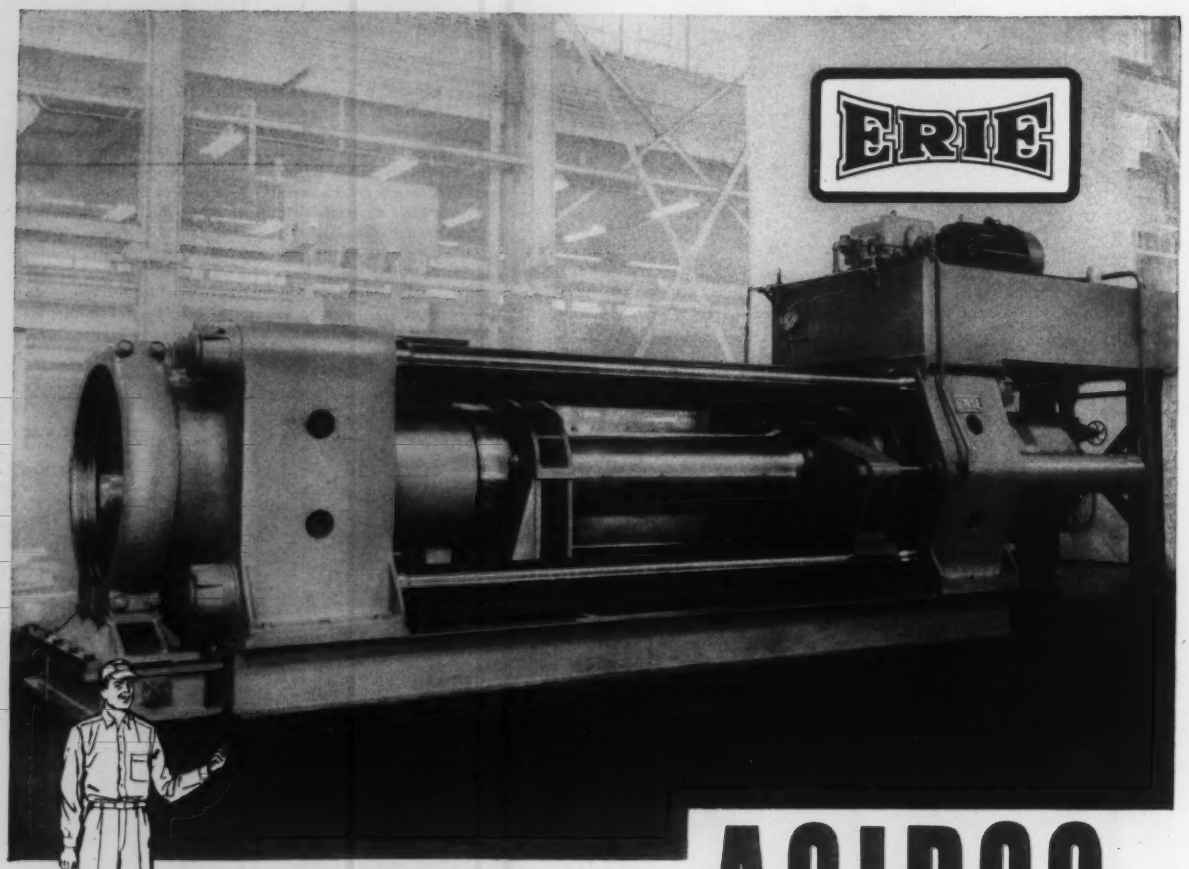
☐ ELECTRUNITE Mechanical Tubing ☐ Electro Paintlok
☐ High Strength Steels ☐ Type HS6460 Powder

Name_____ Title_____

Company_____

Address_____

City_____ Zone____ State_____



another special from ACIPCO

ERIE FOUNDRY CO. PICKS ACIPCO TUBING FOR CARBON EXTRUSION PRESS PLUNGER

You're looking at a new 2000-ton horizontal carbon extrusion press manufactured by the Erie Foundry Company's hydraulic press division. Designed for the production of carbon electrodes, the press features ACIPCO centrifugally spun steel tubing in its main ram plunger.

Custom-spun by ACIPCO, the plunger is 30.50" O.D. with 125 micro-inch finish and 2-5/8" wall thickness. Main ram is 42" in diameter and has a 105" stroke. Produced with heads statically cast at ACIPCO, the plunger's overall length is 144".

Fabricated applications such as this are a specialty with ACIPCO. Completely equipped to solve a wide variety of tubing problems, ACIPCO can serve your needs more efficiently and economically because all its facilities are under one roof. For expert consultation on centrifugally spun tube applications in your field . . . call on ACIPCO.

VERSATILE ACIPCO CENTRIFUGALLY SPUN STEEL TUBES

SIZE RANGE: Lengths up to 410" to meet modern machinery requirements have been produced. OD's from 2.25" to 50"; wall thicknesses from .25 to 4".

ANALYSES: All alloy grades in steel and cast iron, including heat and corrosion resistant stainless steel, plain carbon steel and special non-standard analyses.

FURNISHED: As cast, rough machined, or finished machined, including honing. Complete welding and machine shop facilities for fabrication.

SPECIAL PRODUCTS DIVISION

AMERICAN CAST IRON PIPE CO.

BIRMINGHAM 2, ALABAMA

CUT COSTS

with the Original Mead

MIDGET AIR CLAMP

(Spring Return Air Cylinder)

In assembly jigs and other multiple applications, this new, low cost pressure unit saves countless man-hours. As a work-ejector in many fixtures, it is unexcelled.

Advantages over mechanical clamps

1 **All Air Clamps** in any set-up can be operated by a single master valve—the "lock-up" and release of assemblies is instantaneous.

2 **May be installed in cramped corners** difficult to reach with bulky mechanical clamps. Mead Midget is the most compact air cylinder, for its power, on the market.

3 **Equal ram pressure at any point** along stroke, making special, delicate adjustments unnecessary.

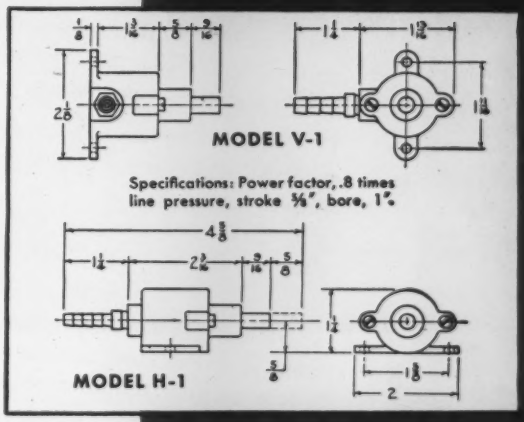
4 **Independent group control.** Any desired group of "Midgets" can be controlled independently of any other group in an assembly—as where primary members of the fixture must be locked up before the secondary members.

5 **Facilitates delicate drill operations.** Air Clamps actuated by foot control valves leave operator's hands free to handle the work pieces.

Send for all the interesting facts on these time-tested, superior Midget Air Clamps.

MEAD SPECIALTIES COMPANY

4114 North Knox Avenue • Dept. MD-119• Chicago 41, Illinois



IMMEDIATE DELIVERY

Single-acting cylinders delivered from stock; double-acting in a few days.

New **MEAD INDUSTRIAL AIR POWER CATALOG**

MEAD

Air Operated Devices

Memo Coupon

MEAD SPECIALTIES CO.

4114 N. Knox Ave., DEPT. MD11 Chicago 41, Illinois

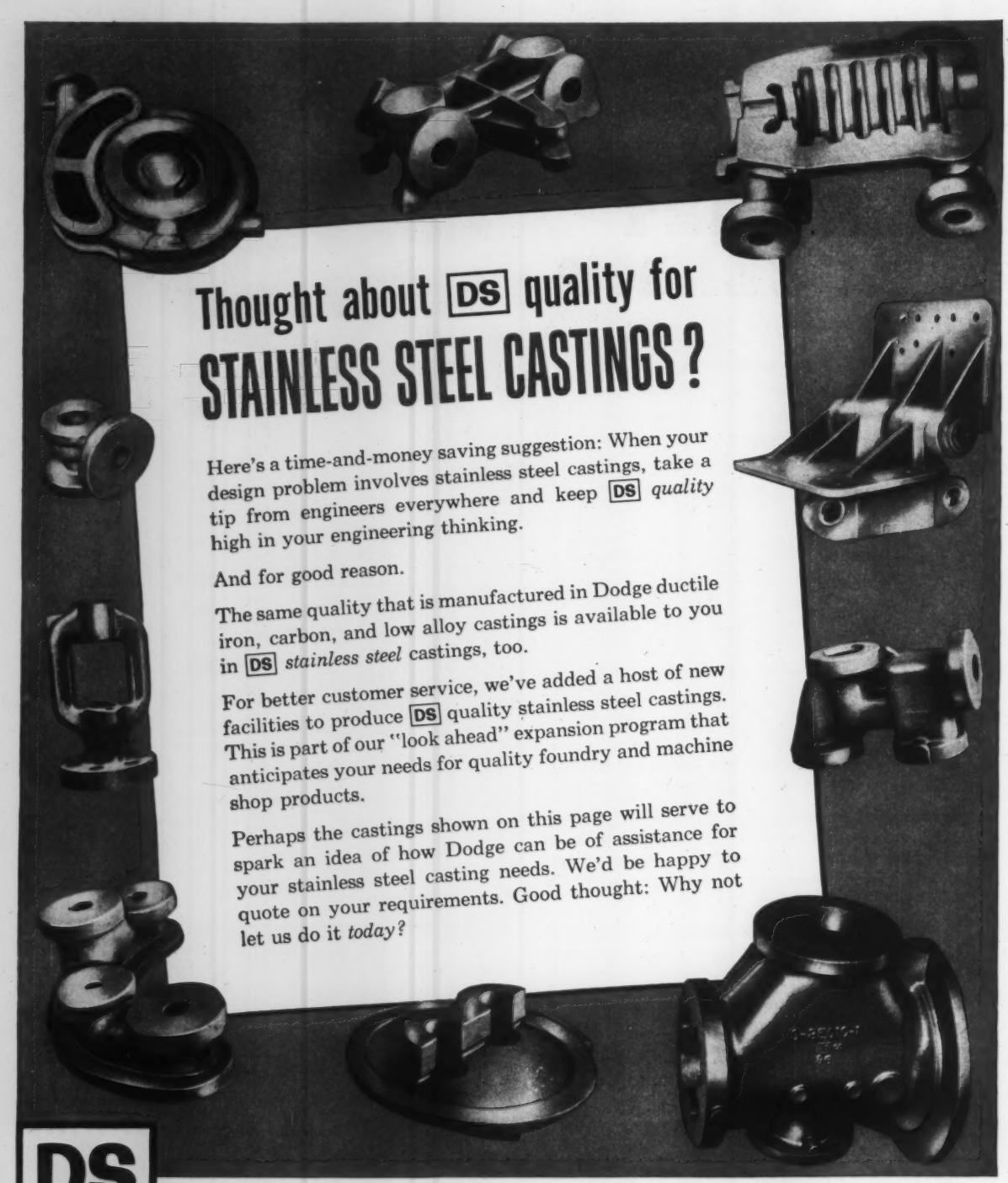
Send free copy of new, colored MEAD INDUSTRIAL AIR POWER CATALOG describing the complete line of famous Mead air-operated devices.

Name_____

Company_____

Address_____

City_____ Zone____ State____



Thought about DS quality for STAINLESS STEEL CASTINGS?

Here's a time-and-money saving suggestion: When your design problem involves stainless steel castings, take a tip from engineers everywhere and keep DS *quality* high in your engineering thinking.

And for good reason.

The same quality that is manufactured in Dodge ductile iron, carbon, and low alloy castings is available to you in DS *stainless steel* castings, too.

For better customer service, we've added a host of new facilities to produce DS quality stainless steel castings. This is part of our "look ahead" expansion program that anticipates your needs for quality foundry and machine shop products.

Perhaps the castings shown on this page will serve to spark an idea of how Dodge can be of assistance for your stainless steel casting needs. We'd be happy to quote on your requirements. Good thought: Why not let us do it *today*?

DS

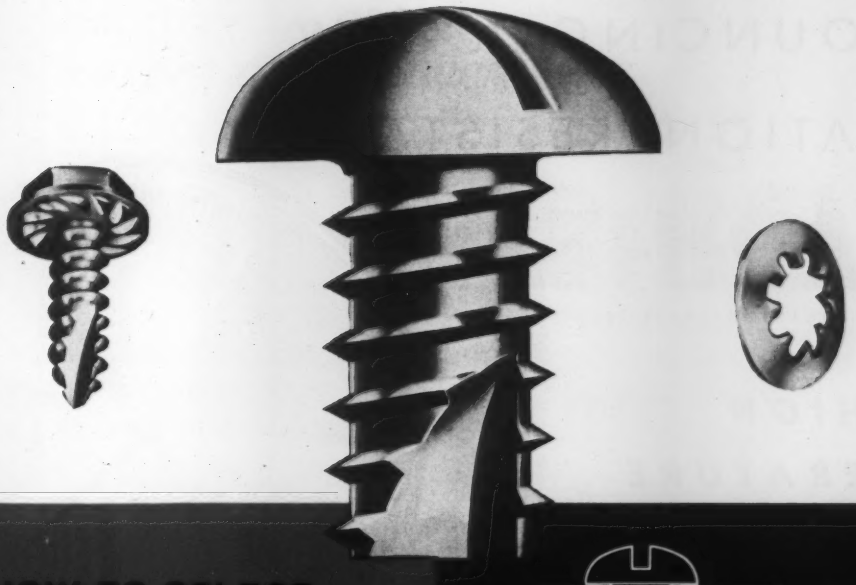
DODGE PRODUCTS

DODGE STEEL COMPANY

6501 State Road • **Philadelphia 35, Pa.** • DEvonshire 2-2200

Stainless

THE MOST IMPORTANT [illegible] IN A STEEL CASTING IS QUALITY



HOW TO SELECT COST-SAVING

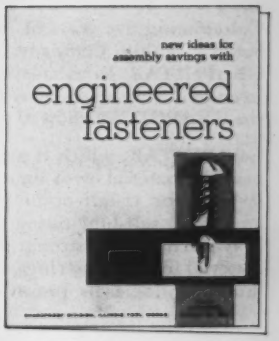
fasteners for plastic

A TYPICAL EXAMPLE:
Cuts its own thread—

Shakeproof's® Type 25 Thread-cutting Screw saves time because it eliminates tapping. Blunt point assures maximum thread engagement and high holding strength when driven into a relatively thin panel.

Shakeproof has pioneered in developing ingenious, cost-cutting fasteners for plastic applications. The screw featured above not only taps its own hole—often it eliminates costly threaded inserts. Another Shakeproof development, the Type 17 self-drilling Nibscrew®, both drills and taps as it is driven. A Shakeproof Dished Lock Washer compensates for differential in expansion between plastic and metal . . . temperature changes won't loosen the assembly.

For highest quality fasteners that assure faster assembly and lower costs investigate the Shakeproof line. There's a Shakeproof fastener to meet your need—or Shakeproof engineers will develop one for your specific application.



WRITE FOR NEW SHAKEPROOF BULLETIN NO. 300
Shakeproof Bulletin 300 shows ten typical, profitable applications of Shakeproof fasteners on products using plastics. Offers free samples for testing. Send for your copy now.

SHAKEPROOF
"FASTENING HEADQUARTERS"®
DIVISION OF ILLINOIS TOOL WORKS
St. Charles Road, Elgin, Illinois
In Canada: Shakeproof/Fastex
Division of Canada Illinois Tools Limited, 67 Scarsdale Road, Don Mills, Ontario

ANNOUNCING A NEW OXIDATION RESISTANT

GRAPHITAR®

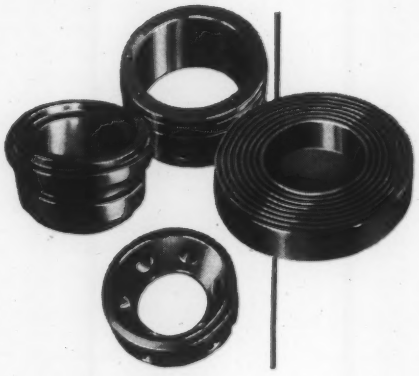
(CARBON-GRAPHITE)

FOR HIGH TEMPERATURE APPLICATIONS

Culminating five years of intensive research, engineers of The United States Graphite Company have developed a new oxidation resistant GRAPHITAR. In exhaustive tests, GRAPHITAR parts were exposed in an oxidizing atmosphere (air) at 1200 degrees F and after 200 hours, the GRAPHITAR showed a weight loss of less than six percent!

GRAPHITAR, which is available in many grades, is a versatile engineering material with unusual and outstanding properties that make it ideal for tough applications. It is non-metallic, resists chemical attack, has self-lubricating properties and a low coefficient of friction. It is mechanically strong, lighter than magnesium and is the perfect material for packing rings, pressure joint seals, clutch release bearings, fluid coupling seals, piston rings, pump liners and vanes.

For more information on this new oxidation resistant GRAPHITAR and its applications, write the GRAPHITAR product manager on your company letterhead.



R-279-1

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 7, MICHIGAN

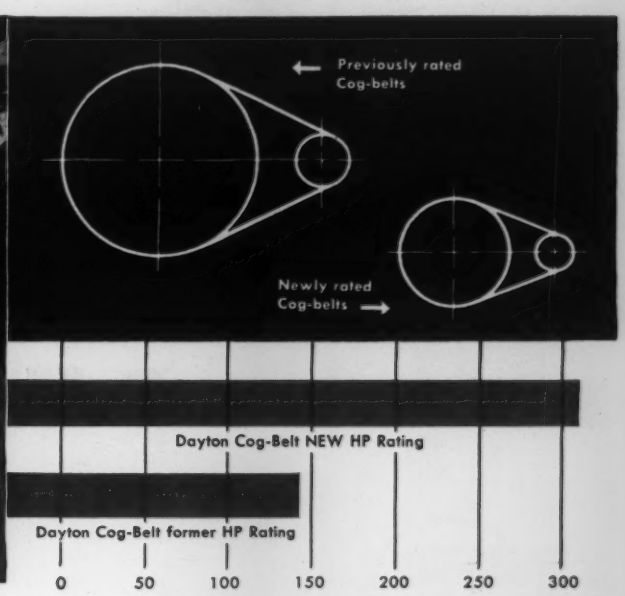
GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDER METALLURGY • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

Savings in cost, weight and space alone will pay you to convert to

DAYTON COG-BELTS®

now rated 200-300% greater HP capacity than standard belts



Seldom has a greater opportunity come along for you to effect drastic savings in first costs and maintenance to equal that now offered by Dayton Cog-Belts. Delivering 2 to 3 times the horsepower of previous-rated standard belts, Dayton Cog-Belts offer major economies in weight, space, equipment and costs.

Two Dayton Cog-Belts now do the work of 4 to 6 previous standard belts. This permits use of narrower sheaves with fewer grooves and a corresponding reduction in the number of belts while maintaining maximum power transmission.

Nor does this up-rating of Dayton Cog-Belts necessitate added cash outlay for special sheaves. In fact—because the tests establishing these amazingly higher ratings were based upon the use of standard-industry sheaves—your existing stocks now have a far greater HP capacity spread than ever before.

Result of a long-term research project by an independent engineering laboratory, the HP capacities of Dayton Cog-Belts can be relied upon fully when calculating your conversion factor. And, if you need assistance in figuring and making the change-over, your local Dayton distributor will be glad to help. He's listed in the Yellow-Pages. Or write for our new brochure that shows how to apply a conversion formula to the existing drive selection tables in Dayton catalog #280-B Handbook of Drive Design.

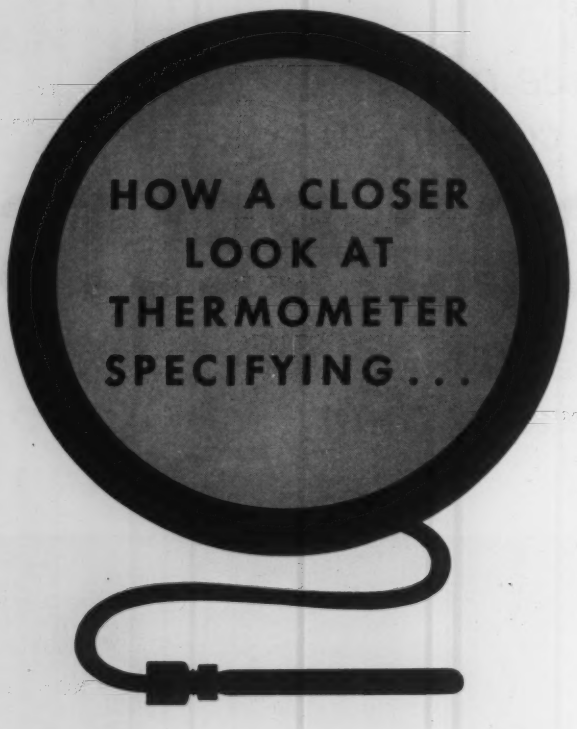
©DR 1959 ®Reg. T.M.

Industrial Dept.

Dayton Industrial Products Co.

Melrose Park, Illinois

A Division of The Dayton Rubber Company

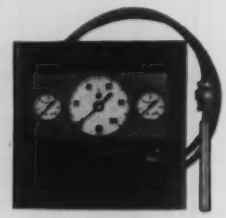


can give you a competitive edge on costs

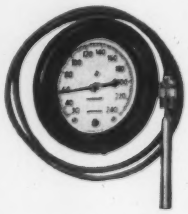
A closer look, for example, at what is available today in thermometer design, performance, accuracy . . . including a closer look at price! Specifically, a closer look at the quality and comprehensiveness of the thermometer line of United States Gauge. Here you will find thousands of standards and specials ranging up to the highest degrees of accuracy . . . in all sizes and styles for all purposes, with exactly the performance you want for your equipment and price. USG thermometers are backed by 54 years' experience in the manufacture of high-precision measuring instruments *which are specified by 6 out of 10 original equipment manufacturers today*. To check on the competitive edge you can get in thermometers, call your nearest USG distributor, listed in the Yellow Pages. Or write direct to United States Gauge.

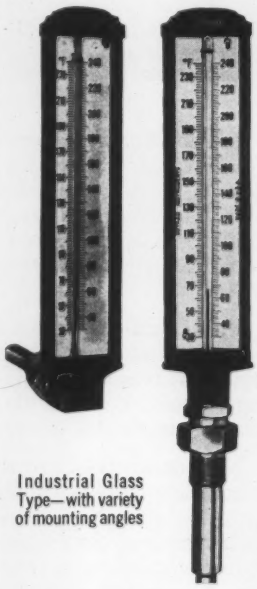
® USG UNITED STATES GAUGE
Division of American Machine and Metals, Inc., Sellersville, Pa.

Find Your Nearest Distributor in the 'Yellow Pages'


Indicating Controllers and Transmitters

Recorders and Recorder-Controllers


Supertherm® Dial Type


Industrial Glass Type—with variety of mounting angles

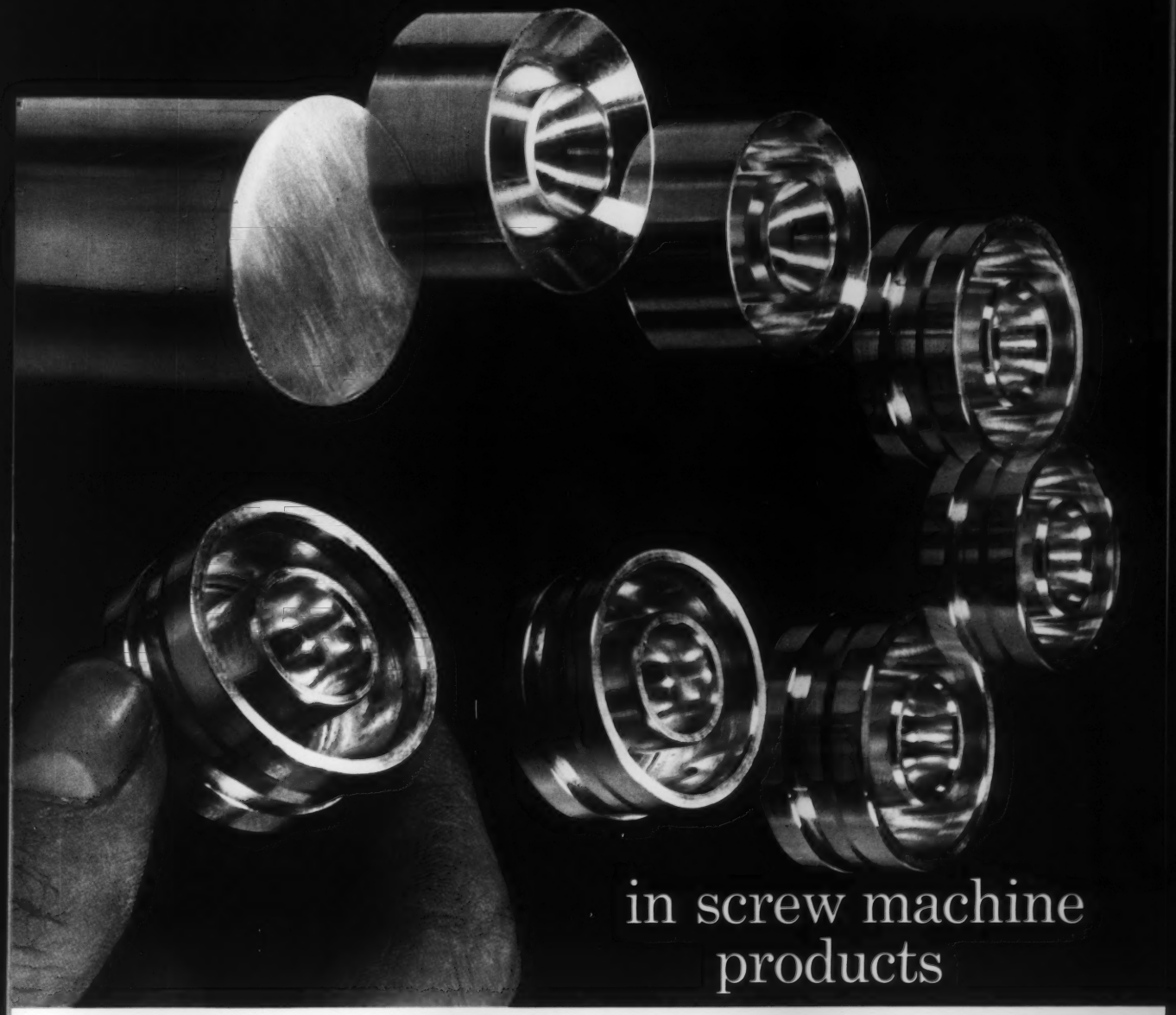
Drawn Case Thermometer (Brass or Steel)

Direct-Connected Types

Dial Type with Alarm

Circle 463 on Page 19

Circle 464 on Page 19→



in screw machine products

Alcoa puts the metal where you want it

This aluminum piston for an automotive air-conditioning compressor shows how far Alcoa goes to put the metal where you want it. Not just in primary screw machine operations, complex and demanding as they were, but on through a series of exacting secondary operations that enabled us to deliver a completely finished part.

Using $1\frac{7}{16}$-in. diameter 2014-T4 cold finished bar on a six-spindle automatic, we handled the forming, trepanning, drilling, facing and counterboring. Then we tackled the rest of the job—drilling and deburring two $\frac{1}{16}$-in. cross holes. This was followed by coining the ball seat at a specified tonnage in order to insure proper assembly without distortion. Centerless grinding was then performed to a total tolerance of half a thousandth of an inch (plus or minus 0.00025 in.). All finished? Not by our standards. After final inspection, we cleaned every piece and packed it with meticulous care to prevent damage in transit, insuring safe and sound arrival.

Whether it's screw machine parts, forgings, castings, extrusions or impacts, Alcoa can put the metal where you want it—precisely and economically. The payoff may be fewer rejects, new flexibility in design, less waste in production, a best-selling product—or all four. To draw on Alcoa's file of ideas and Alcoa facilities, write today: Aluminum Company of America, 920-K Alcoa Building, Pittsburgh 19, Pa.

Alcoa puts the metal where you want it—in castings, forgings, impacts, extrusions and screw machine parts.

ALCOA ALUMINUM

ALUMINUM COMPANY OF AMERICA

For exciting drama watch "Alcoa Presents" every Tuesday, ABC-TV, and the Emmy Award winning "Alcoa Theatre" alternate Mondays, NBC-TV

Your Guide to the Best in Aluminum Value

Photo courtesy Boeing Airplane Co.

vibration / shock / noise control for missile environments

***O**perational missile environments and extremely accurate control equipment* demand *advanced techniques in vibration/shock/noise control. Pioneered by Lord, these techniques are applied to mounting system projects on a great variety of equipment.*

ADVANCED TECHNIQUES were used to develop special elastomeric mounting system for magnetron on *Bomarc*. Surface-to-air environment of this Mach 2.5 missile requires isotropic performance, excellent damping and high natural frequency (above 60 c.p.s.). Lightweight suspension isolates magnetron from extreme disturbances including shock, high-frequency vibration, random excitations and sustained accelerations to 10G.

SECOND GENERATION VEHICLES are introducing extremely sophisticated requirements for shock and vibration protection. Utilizing experience gained on *Atlas, Titan, Hawk, Jupiter, Talos and Bomarc*, LORD is now developing high-performance mounting systems for such advanced projects as *Minuteman* and *Mercury*. Selection of LORD to custom design, test and manufacture mounting systems for these projects reflects LORD's outstanding capabilities for *reliability protection.*

LORD CAPABILITIES have been utilized on many successful projects involving all types of mounting systems: center-of-gravity, rectilinear, focalized, high-returnability, active, integrated. Rigorous specifications have included protection against in-flight, storage and transport environments, broad temperature conditions from −65° to + 500°F, "white noise", 100G shock loads, broad frequency spectrums, 25G superimposed sustained accelerations, random excitations and rotational inputs.

If your space age project requires reliability protection, utilize the capabilities available at LORD—specialists in vibration/shock/noise control. Contact the nearest LORD Field Office or the Home Office, Erie, Pa.

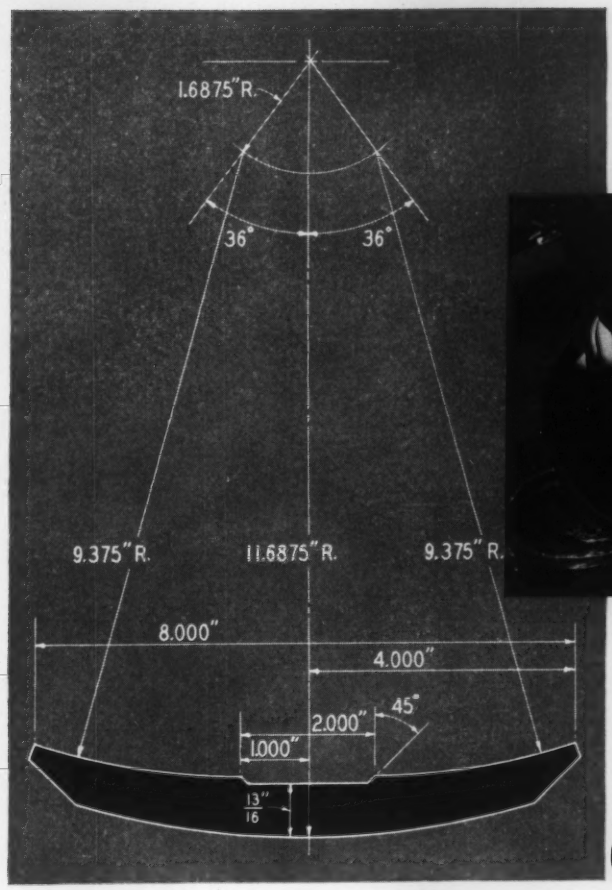
LORD®

FIELD ENGINEERING OFFICES

ATLANTA, GEORGIA · CEdar 7-9247
BOSTON, MASS. · HAncock 6-9135
CHICAGO, ILL. · MIchigan 2-6010
DALLAS, TEXAS · Riverside 1-3392
DAYTON, OHIO · BAldwin 4-0351
DETROIT, MICH. · DIamond 1-4340
KANSAS CITY, MO. · WEstport 1-0138
LOS ANGELES, CAL. · HOllywood 4-7593
NEW YORK, N. Y. · Circle 7-3326
PHILADELPHIA, PA. · PEnnypacker 5-3559
SAN FRANCISCO, CAL. · EXbrook 7-6280
WINTER PARK, FLA. · MIdway 7-5501

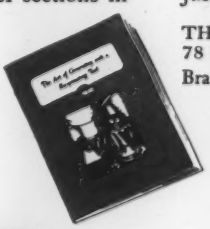
"In Canada—Railway & Power Engineering Corporation Limited"

LORD MANUFACTURING COMPANY · ERIE, PA.



2 RADII, 3 SURFACES Cut in One Operation

Difficult machining job? Shop management at Blanchard Machine Company, Cambridge, Mass., made it a simple production operation using a standard Fellows Gear Shaper. Eight of these segments are shaped at one time, as shown in the photograph. A special gear shaper cutter generates all of the internal surfaces in one revolution of the work table. The segments are then simply cut apart, drilled and tapped. The pieces are segment clamps to hold grinding wheel sections in the chuck of the Blanchard Surface Grinder. The same Fellows Gear Shaper, using appropriate cutters, can produce an almost infinite range of non-circular shapes, simple or complex, as well as internal and external spur, helical and herringbone gears, and gears close to shoulders or in recesses. The advantages of the Gear Shaper are illustrated in "The Art of Generating with a Reciprocating Tool." If you would like a copy just write us.



THE FELLOWS GEAR SHAPER COMPANY
78 River Street, Springfield, Vermont
Branch Offices:
1048 North Woodward Ave., Royal Oak, Mich.
150 West Pleasant Ave., Maywood, N. J.
5835 West North Ave., Chicago 39, Ill.
6214 West Manchester Ave., Los Angeles 45, Cal.

THE PRECISION LINE **Fellows** *Gear Production Equipment*

What will they think of next!

... what new modifications of the Fenwal 541 Temperature Controller will equipment designers ask for?

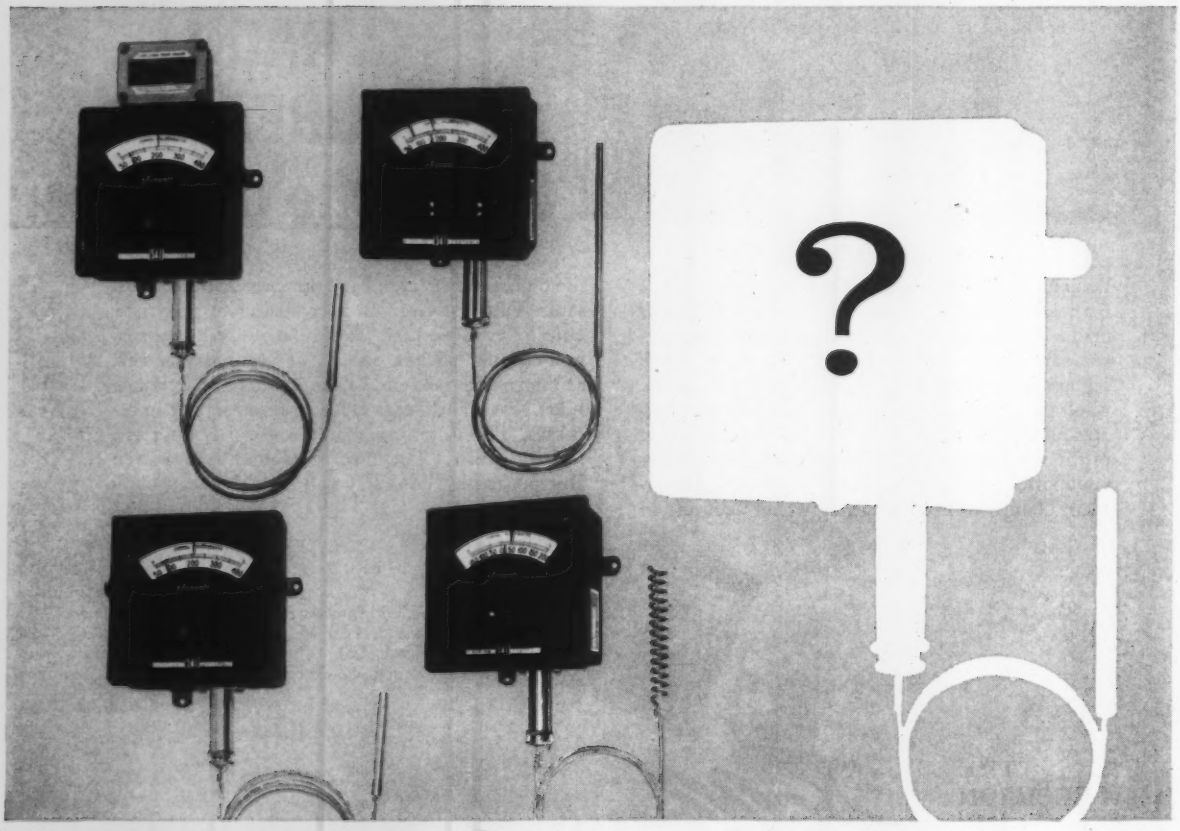
Luckily our engineers designed this liquid-filled bulb and capillary tube indicator controller for easy adaptation. It's been specified for applications ranging from gas burner control to fuel temperature control in missile ground support equipment. *Yet, basically, it's always the same, simple "black box"!*

The secret is case space. Room for up to 3 snap switches providing 3-point control. Nine-pin connector available for quick connect/disconnect to power source. Choice of 5 standard temperature ranges between −150° to +700°F (or special ranges). *Can control as many as four circuits simultaneously!*

Also . . . welded steel, splash and dust resistant case in black or gray crinkle finish, white enamel, or special color. Available completely fungus resistant. Mounts flush or on panel. Pilot light, if desired and . . . *every detail for each specific application!*

Design this competitively priced, high-efficiency controller into *your* product. Details from Fenwal Incorporated, 1911 Pleasant Street, Ashland, Massachusetts.

All moving parts of the rugged Fenwal 541 Temperature Controller operate in opposition . . . compensate for wear and maintain perpetual high accuracy. Ratings: 15 and 20A-125-250VAC; .50A-125VDC; .25A-250VDC.



ANOTHER EXAMPLE OF HOW **Fenwal** CONTROLS TEMPERATURE . . . PRECISELY

Circle 467 on Page 19

Here, boiling nitric acid is used to evaluate the corrosion resistance of Jessop stainless steel plate.

"How Jessop Tests Stainless Steel in Boiling Nitric Acid"

L. W. Cooper, Chief Metallurgist

"From experience, our customers know this is a fact: Specify Jessop for specialty steels . . . and then relax! Of the many reasons *why* this is true, here's one . . .

"In evaluating corrosion resistance, one of the procedures we use is the ASTM boiling nitric acid test. Standard and simple? Yes. But expert *evaluation* is of great importance to the customer. That's why, at Jessop, a top metallurgist closely supervises each of the five 48-hour test periods.

"*Overly cautious?* Because we're overly cautious in *every* phase of steel production and quality control, Jessop has earned the reputation for producing specialty steels tailor-made to the most exacting specs — *Specify Jessop . . . and then relax!*"

Checking the grain size of tool steel, this Jessop metallurgist uses a microscope with a camera attachment. VMA 6787

Green River Steel Corporation
Jessop Steel of Canada, Ltd.
Jessop Steel International Corporation
Steel Warehousing Corporation, Chicago

JESSOP
STEEL COMPANY
Washington, Pennsylvania

Stainless, alloy, tool, cast-to-shape, clad, and forging steels, ground flat stock and other specialty steels

Circle 468 on Page 19

WHO MAKES FINE MOTORS THIS SMALL?

Globe Industries makes motors this small to make your design more compact, reliable and salable. If you make miniature instrument packages for space exploration — if you build airborne and ground support equipment—if you want to design smaller typewriters, computers, recorders or other products, look at these 3 motors:

TYPE VS—The smallest, most powerful precision miniature d.c. motor for its size. Only 7/16" flat, four VS motors fit in a regular cigarette pack with room to spare. It has the power to lift its own weight to the top of the Empire State Building in 1 minute! Typical continuous torque—.25 oz. in.; typical intermittent torque—.5 oz. ins. We can design gear units, governors and brakes to meet MIL specs also.

TYPE SS — Only 7/8" in diameter, Type SS d.c. motors typically produce continuous duty torques of .3 oz. in.; intermittent torques to .6 oz. ins. With the basic Type SS motor you can specify any of 21 planetary gear speed reducers or 28 spur gear speed reducers. Governors and brakes are available also. Designed to meet MIL specs.

TYPE MM — The most widely used precision 1¼" d.c. motor in the world, MM motors typically produce .5 oz. in. in continuous duty applications — 1.0 oz. in. intermittent duty. Choose from 101 ratios of planetary gear speed reductions. Brakes, governors and clutches can be included. MIL specs are invited.

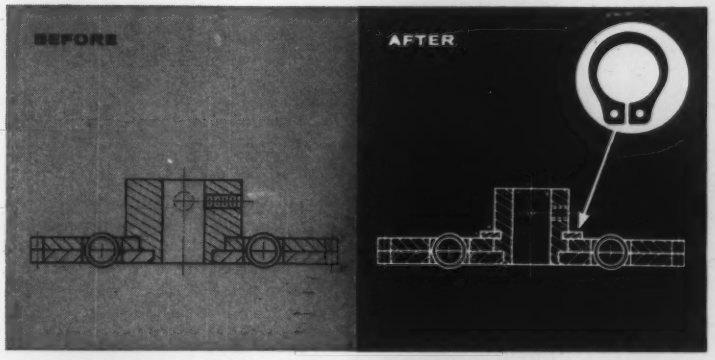
For details about these motors request Bulletin VSM. Globe Industries, Inc., 1784 Stanley Ave., Dayton 4, Ohio.

GLOBE INDUSTRIES, INC.

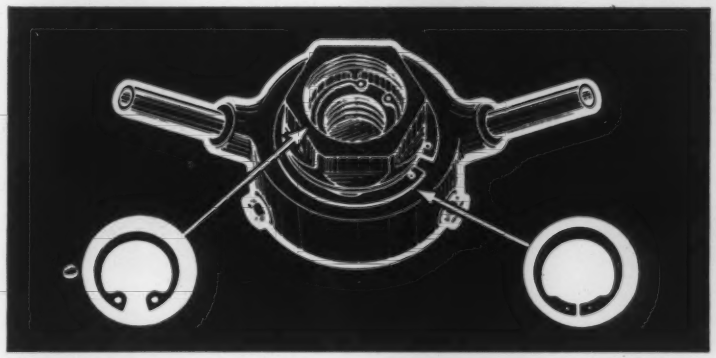
PRECISION MINIATURE A.C. & D.C. MOTORS. ACTUATORS. TIMERS. GYROS. STEPPERS. BLOWERS. MOTORIZED DEVICES

GLOBE

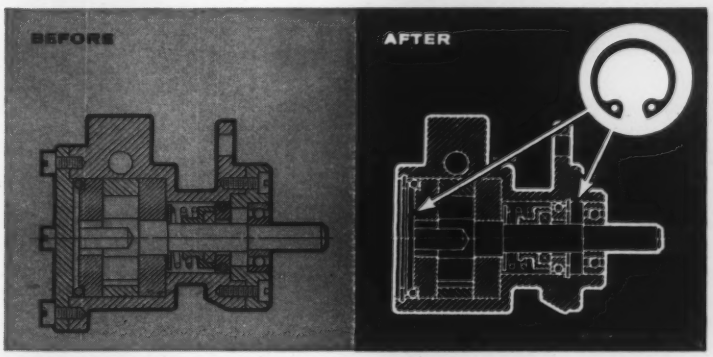
Circle 469 on Page 19



Gear assembly improved. A Waldes Truarc Series 5100 retaining ring in this anti-backlash gear assembly eliminates machining and staking operations, reduces hub size, and allows easy disassembly, after gears are cut as a unit, for faster, better deburring. **Typical savings: $350.00 per 1000 units.**



Threaded retainers eliminated. In this self-sealing coupling, costly internal and external threaded retainers were eliminated by easy-to-apply internal (Series 5000) and external (Series 5108) Truarc retaining rings. **Savings per unit amounted to $4.02.**



End-cover design simplified. In this general-purpose pump, two Waldes Truarc, Series 5000, internal retaining rings make possible the elimination of two cover-plate castings (plus machining) and eight screws (plus drilling and tapping). Weight and dimensions are reduced and assembly and disassembly are greatly facilitated. **Typical cost savings: $1.48 per unit.**

©1959 WALDES KOHINOOR, INC.

WALDES
TRUARC®
RETAINING RINGS
Waldes Kohinoor Inc., Long Island City 1, N. Y.

Designing for axial assembly with Truarc retaining rings

eliminates parts, machining, speeds assembly, simplifies maintenance

The proper application of retaining rings on or in axial assemblies can often effect startling simplifications and economies in design when compared to corresponding designs with conventional fastening devices. A few typical examples, using basic types of retaining rings, are shown in the accompanying drawings.

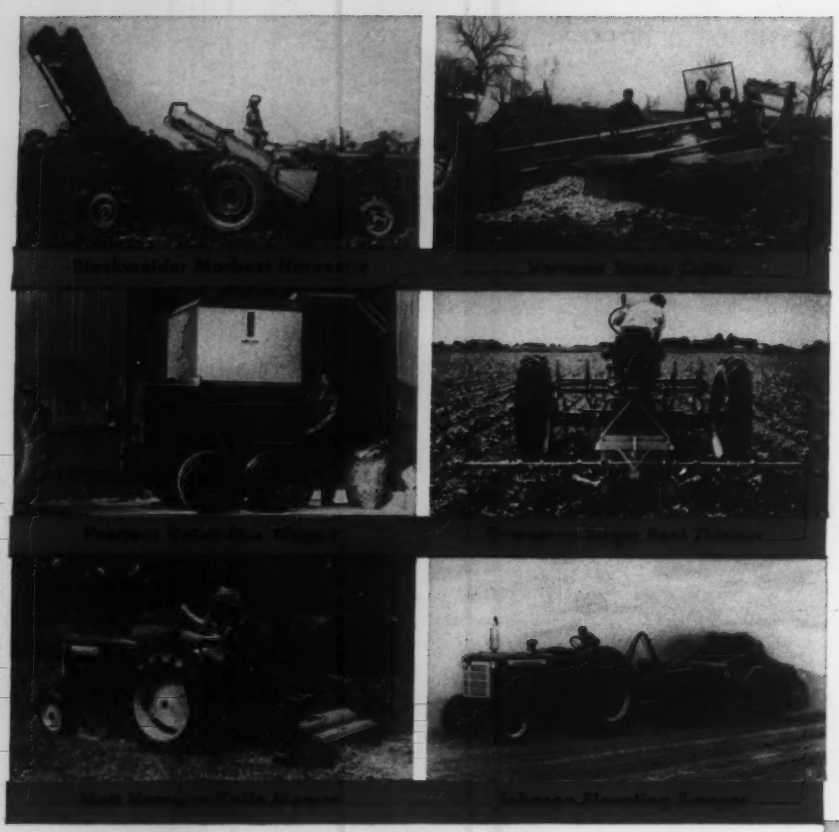
Threading, tapping, drilling, facing and other costly, time-consuming operations can be eliminated. Retaining rings are already in wide use in a tremendous variety of equipment ranging from household products to high-precision military gear designed for use under the most severe environmental conditions. They are quickly and simply installed in easily cut grooves which can often be machined simultaneously with other operations. The rings can frequently replace bulkier, more costly fastening devices —such as nuts, screws, studs, threaded sleeves and retainers, cotter pins, set collars, rivets and machined shoulders.

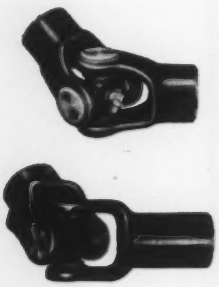
What's more, rings frequently make practical designs which could be achieved with no other known fastening device.

Although the ring types shown here are basic, Truarc retaining rings come in 50 functionally different types, as many as 97 different sizes within a type, 6 metal specifications and 13 finishes. You'll find detailed descriptions of Truarc retaining rings and assembly tools, plus more than 70 typical applications in the new 24-page catalogue RR10-58. Write for your copy today.

And remember, Waldes engineers are always ready to help you solve your application problems—whether it involves one of the standard Truarc rings or a "special" to fit your particular requirements. Waldes Kohinoor, Inc., 47-16 Austel Place, Long Island City 1, N. Y.

TRUARC RETAINING RINGS...THE ENGINEERED FASTENING METHOD FOR REDUCING MATERIAL, MACHINING AND ASSEMBLY COSTS





Specialized implements lighten many chores with power through

BLOOD BROTHERS Drive Lines

Every year, new implements are built by the smaller "specialty" manufacturers. And with p.t.o. power—through jointed drive assemblies—their economy strongly appeals to the farmer's purse.

Most implements, you'll find, are equipped with Blood Brothers Jointed Drive Assemblies. That's because both Rockwell-Standard engineers and the implement builders themselves cooperate toward one end: Fully dependable performance at reasonable cost.

Whether you build specialized implements—or day-to-day working machines—it will pay you to consult Rockwell-Standard!

For general information, request Bulletin 557.

ROCKWELL-STANDARD CORPORATION

Blood Brothers Universal Joints

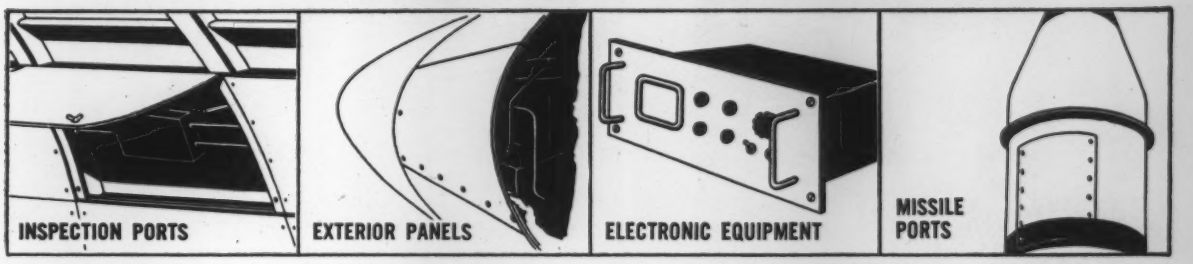
ALLEGAN, MICHIGAN

© 1959
Rockwell-Standard Corp.

Rockwell-Standard engineers can help lighten your drive line design chores too! Call them . . .

FLIGHT-PROVED RELIABILITY . . .

LION *Quarter-turn* FASTENERS FOR SECURING REMOVABLE SECTIONS



Southco's Lion Quarter-turn Fasteners provide quick access and reliable securing of hinged or completely removable panels. Resistance to severe heat, shock and vibration, and a high strength-weight ratio make these unique fasteners ideal for use in private, commercial or military aircraft and missiles . . . for ground production and control or airborne applications.

Lion Fasteners consist of three parts . . . a one-piece, swaged-nose stud; a retainer; a floating receptacle which is riveted or welded in place. Installation requires no special tools . . . is simplified by a permissible float of .070".

SWAGED NOSE

Case hardened one-piece stud with swaged nose has no milled sections, inserts, or cross pins . . . requires no wire spring to hold it in locked position. Lion Fasteners offer the highest weight-strength ratio available.

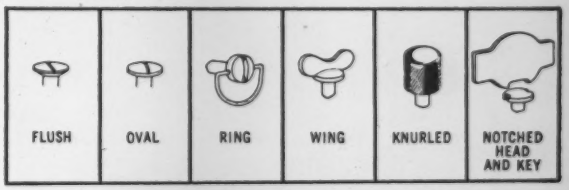
2 TYPES AVAILABLE

LION NO. 2 FASTENER
For use where space is limited and where weight must be kept at a minimum.

LION NO. 5 FASTENER
For heavy-duty applications where good tensile and shear strength are required.

FULL RANGE OF HEADS

Lion No. 2 Fastener available with flush, oval or wing type. No. 5 with flush, oval, ring, wing, knurled or notched head and key.



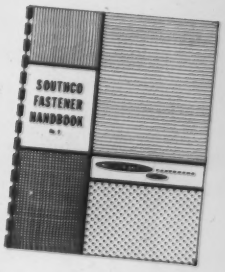
OTHER SPECIFICATIONS

LION NO. 5 QUARTER-TURN FASTENERS CONFORM TO MIL. SPEC. MIL-F-5591A (ASG) . . . ARE ON THE GOVERNMENT'S QPL . . . ARE CAA APPROVED FOR COMMERCIAL AND PRIVATE AIRCRAFT USE.

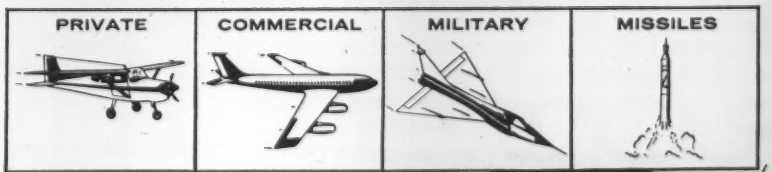
MATERIAL: Cadmium-plated case-hardened steel.

FREE!

FASTENER HANDBOOK



Send for your free copy of Southco Fastener Handbook No. 9. Gives complete engineering data on Lion Fasteners and many other special fasteners. Write to Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pa.



LION *Aviation* FASTENERS

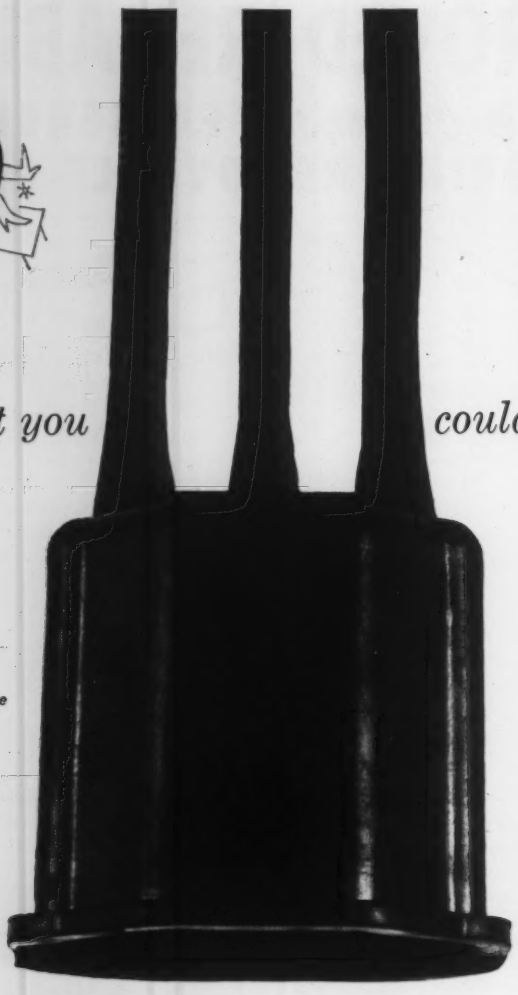
one of the SOUTHCO FASTENERS LION

©1958

Cushion

Resist Weather

Ever think what you *could do with* **MOLDED RUBBER?**



Insulate

...and much more

Seal

Some of today's most significant product improvements are starting with a decision to try molded rubber. You have an amazing choice of physical properties when specifying custom rubber, and its ease of molding simplifies countless design problems. Roth research experts will tailor a special rubber exactly to your need . . . rubber that absorbs sound and vibration, provides flexibility, remains elastic in extremes of heat or cold, withstands abrasion, high voltage corona, solvents, oils, or chemicals. Roth production technicians guarantee flawless, precision molded products. Large or small runs are produced efficiently, economically, on schedule.

SEND FOR THIS NEW BOOKLET! It tells how Roth's unique engineering resources and flexible production facilities can give you invaluable help . . . shows why it pays to deal with people who *know* rubber. Send today for your copy of "New Design Opportunities through Roth Engineering-in-Rubber."

ROTH

RUBBER COMPANY

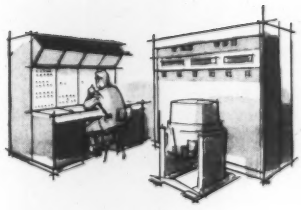
1860 S. 54th Ave., Chicago 50, Ill., BIshop 2-1060

Division of Vapor Heating Corporation

Six million pounds at least — that's the cumulative force from *thousands* of MB shakers in the field. Accompanying MB power amplifier output has rocketed beyond *two million watts.*

MB output is actually the measure not only of vibration testing's progress in 10 years, but also of its great *importance* to reliability. In fact, virtually the entire missile vibration testing program rests on MB exciters.

In producing the widest scope of complete systems for simple and complex motion testing, MB has accumulated unmatched experience in the techniques of testing. It is applied with engineering imagination, administered through the largest field force of vibration specialists. It is ready to help you.



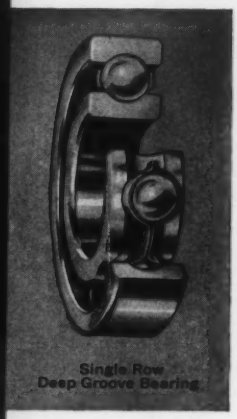
Pioneer and leader in the field of vibration

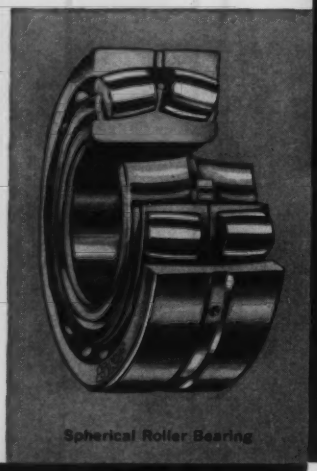
MB ELECTRONICS

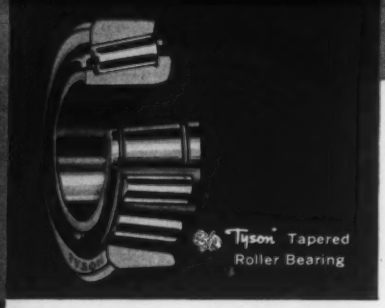
A DIVISION OF TEXTRON ELECTRONICS, INC., 1056 State Street, New Haven 11, Conn.

Circle 474 on Page 19

What's "special" about these standard SKF bearings?







They all have exclusive features. Where else, for example, can you get the 33⅓% higher capacity available in standard SKF spherical roller bearings?

✻Or, take the cylindrical roller bearing. This type provides high radial capacity and minimum shaft friction. Controlled shaft end float within the bearing is a natural advantage of this design.

Yet this is SKF's standard cylindrical roller bearing, promptly available in 154 sizes ranging from just under 1" to 6" (bore). In the double row it's 1" to 9.5",

Why not get the complete facts on these "special" but standard (and economical) bearings? For details, call any of the 25 SKF sales offices today. 5923

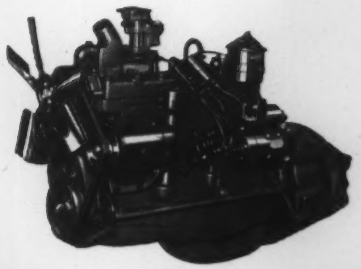
Spherical, Cylindrical, Ball, and "Tyson" Tapered Roller Bearings

EVERY TYPE—EVERY USE

SKF®

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

®REG. U. S. PAT. OFF.



IND. 32 (6)
265 cu. in.
displacement

DEMAND
for
CHRYSLER POWER
at all
times!

IND. 56-A (V-8)
354 cu. in.
displacement

Why?

- *More power per cubic inch displacement*
- *Longer engine life*
- *Service and parts available within 8 hours*

MORE POWER. Chrysler Industrial Engines develop more horsepower per cubic inch displacement than rival engines. Chrysler's famous fluid coupling and torque converter handle extreme load demands with peak efficiency.

LONGER LIFE. Full filtering oil system, special hardened crankshaft and bearing material, superfinished moving parts provide thousands of extra hours of trouble-free operation. Chrysler power is tailored to individual applications through thousands of combinations of options and accessories.

SERVICE. New Chrysler industrial engine centers and dealer network virtually eliminate down time losses. Parts and service available anywhere in the United States within 8 hours. The fastest, most efficient service in the industry.

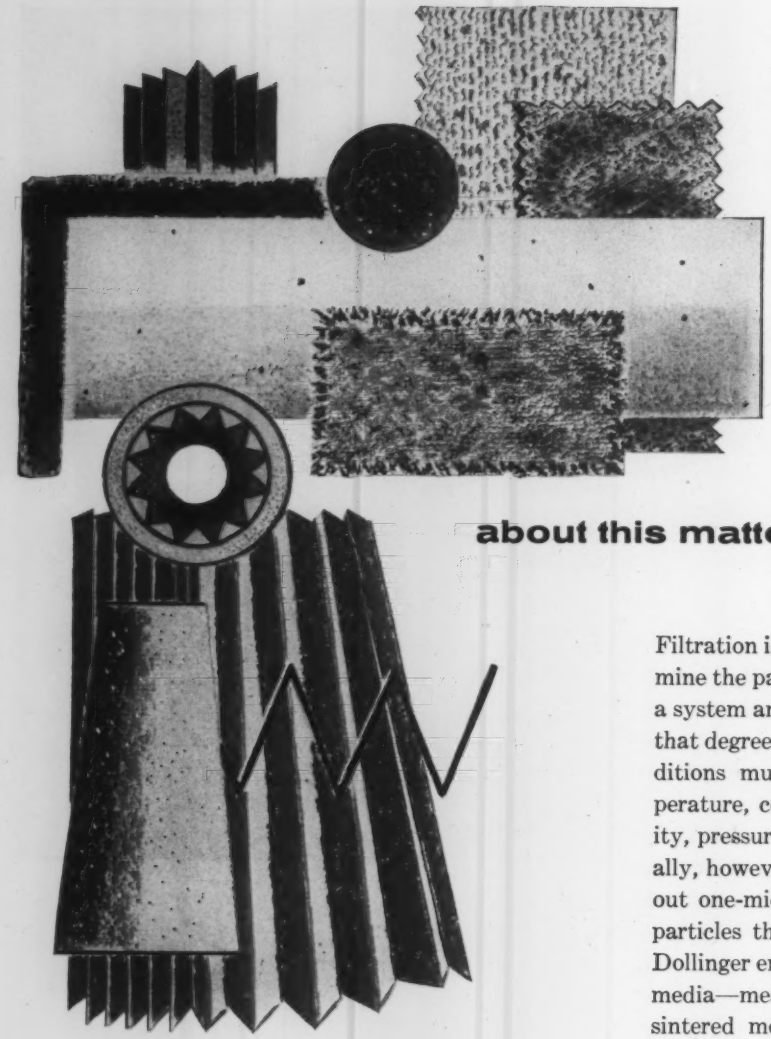
Investigate big output Chrysler Industrial Engines for power in the 230 to 354 cu. in. displacement range. Discover what Chrysler engines can do for your product!

NEW Chrysler Product Line Catalog gives complete details on all engines, all optional equipment. Enables Chrysler sales engineer to "build" and price an engine for your individual application—right at your desk. A call or letter will bring a Chrysler sales engineer to your office.

NOW AVAILABLE FROM CHRYSLER—
DIESEL ENGINES, 9 to 300 h.p. (16 models)

CHRYSLER

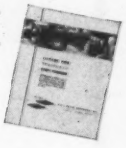
MARINE AND INDUSTRIAL ENGINE DIVISION
CHRYSLER CORPORATION · DETROIT 31, MICHIGAN



about this matter of filter media...

Filtration is all a matter of *degree*. You determine the particle size that can be tolerated in a system and then use a medium which gives that degree of filtration. Of course, other conditions must also be considered, i.e. temperature, corrosiveness, rate of flow, viscosity, pressure, allowable pressure drop. Basically, however, it's whether you want to filter out one-micron particles or strain one-inch particles that first determines the medium. Dollinger engineers make use of 110 standard media—mesh, woven cloth, felt, porous glass, sintered metals, paper, activated charcoal, etc. From this vast array, the most practical and economical medium can be selected and engineered into a unit which will meet all your filtration requirements.

Why not give us the facts, and see if Dollinger's 35 years' experience can help you? Who knows, a standard Dollinger Filter may be tailor-made for your job. Write for new composite catalog. Dollinger Corporation, 26 Centre Park, Rochester 3, N. Y.



PROTECTOMOTOR

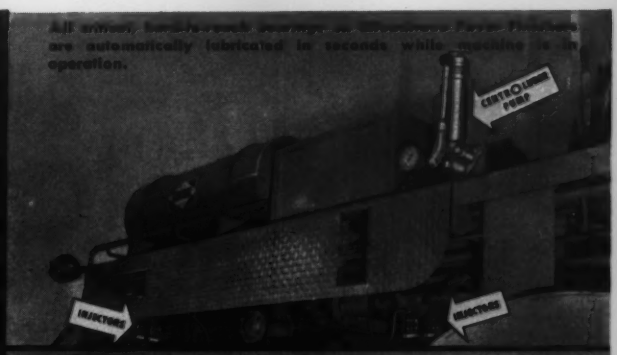
STAYNEW FILTERS

DOLLINGER

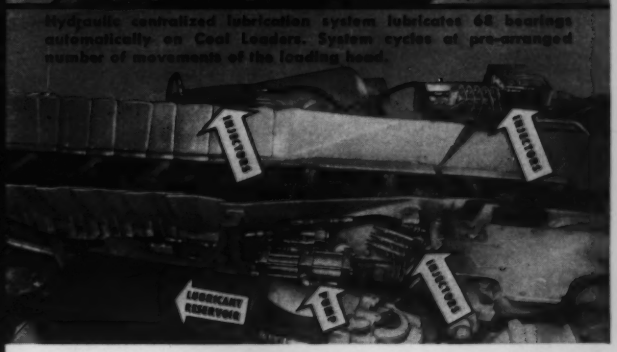
SPECIALIZING IN DRY TYPE FILTERS FOR 35 YEARS

LIQUID FILTERS • PIPE LINE FILTERS • INTAKE FILTERS • HYDRAULIC FILTERS • ELECTROSTATIC FILTERS • MIST COLLECTORS • DRY PANEL FILTERS • SPECIAL DESIGN FILTERS • VISCOUS PANEL FILTERS • LOW PRESSURE FILTERS • HIGH PRESSURE FILTERS • AUTOMATIC VENTILATION FILTERS • NATURAL GAS FILTERS • SILENCER FILTERS

LINCOLN POWER LUBRICATION SYSTEMS



All critical, hard-to-reach bearings on Bituminous Power Finishers are automatically lubricated in seconds while machine is in operation.



Hydraulic centralized lubrication system lubricates 68 bearings automatically on Coal Loaders. System cycles at pre-arranged number of movements of the loading head.

Over 200 bearings on this 55-cu. yd. Power Shovel are automatically lubricated at pre-set, time clock controlled intervals. (Circle Roller Bearings, illustrated.)

All lubrication points on this overhead Crane are automatically lubricated in 10 seconds with five strokes of the lubricant pump handle.

Progressive manufacturers of many types of heavy-duty machinery and equipment are adding more "sales power" to their products by incorporating low-cost Lincoln Power Lubrication Systems in their original designs.

With new equipment costs at an all-time high and depreciation allowances brutally low, your customers need and want design features that will result in longer, more productive machine life.

These proven methods of automatic lubricant application assure longer service-life, eliminate down-time for lubrication, cut operating costs, guarantee greater customer satisfaction. Lincoln Centralized Systems are sealed from pump to bearing, providing refinery-fresh lubricant to all points simultaneously. They are available for manual, semi-automatic or fully automatic application.

Choose from the most complete line of Power Lubrication Systems on the market. Add extra sales appeal to *your* original equipment by designing with Lincoln. Mail the coupon now for full details.

Lincoln

LINCOLN ENGINEERING CO
Division of The McNeil Machine & Engineering Co.
St. Louis 20, Missouri

Mail This Coupon Today!

LINCOLN ENGINEERING COMPANY
5736 Natural Bridge Avenue
St. Louis 20, Missouri

Please send my copy of Catalog 82, illustrating and describing Lincoln Power Lubrication Systems for heavy-duty equipment.

Name.....Title.....

Company.....

Address.....

City.....Zone.....State.....

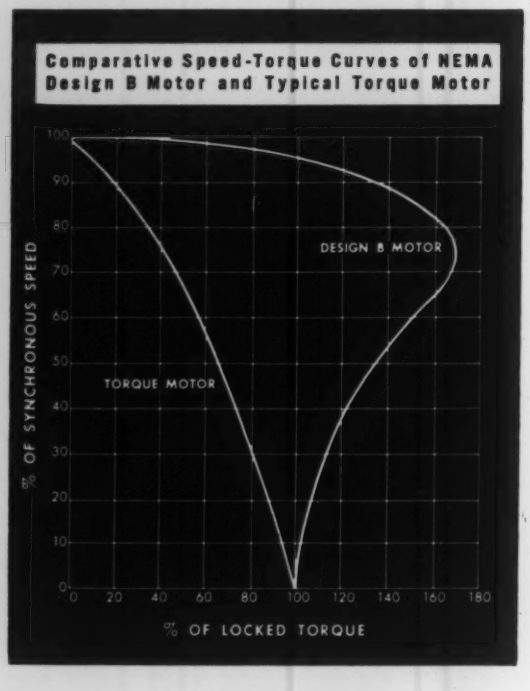
Circle 478 on Page 19

SELECTING TORQUE MOTORS

The torque motor, unlike any other electric motor, is a special from the word go. That situation alone makes Peerless one of the best sources for torque motors in ratings from 2 oz. in. to 200 lb. ft.

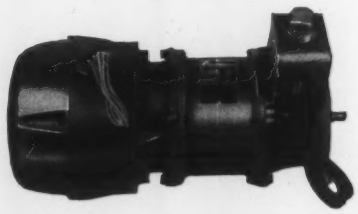
Torque motors deliver maximum rated torque without damage to the windings when stalled across the line at full voltage for predetermined periods. Peerless also builds torque motors which provide a nearly constant torque while operating at less than synchronous speeds.

All standard frame sizes; all types of mountings; high torques; special paint and varnish treatments; and Class A, B and H insulation are available from Peerless. Torque motors require unusually close cooperation between the motor supplier and the customer's engineers. This cooperation is a Peerless specialty. We will work with you to produce the one torque motor that powers your product best.

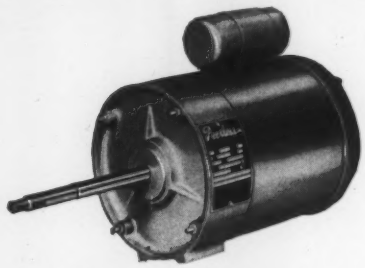


The speed-torque curve varies from that of a conventional motor. The torque motor curve is almost linear. Maximum torque occurs at the stalled position. For this reason, torque motors are used most often where a holding or resisting force is required.

Weather-Tight Special Flange

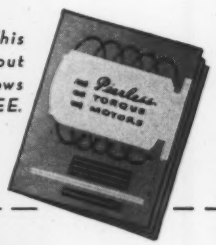


Explosion-Proof Torque Motor with Brake



Special Flange Reversing Hoist Motor Single Phase

NEW TORQUE BULLETIN-This bulletin outlines basic facts about Peerless torque motors and shows applications. It is available FREE. Write for it today.



ELECTRIC MOTOR DIVISION

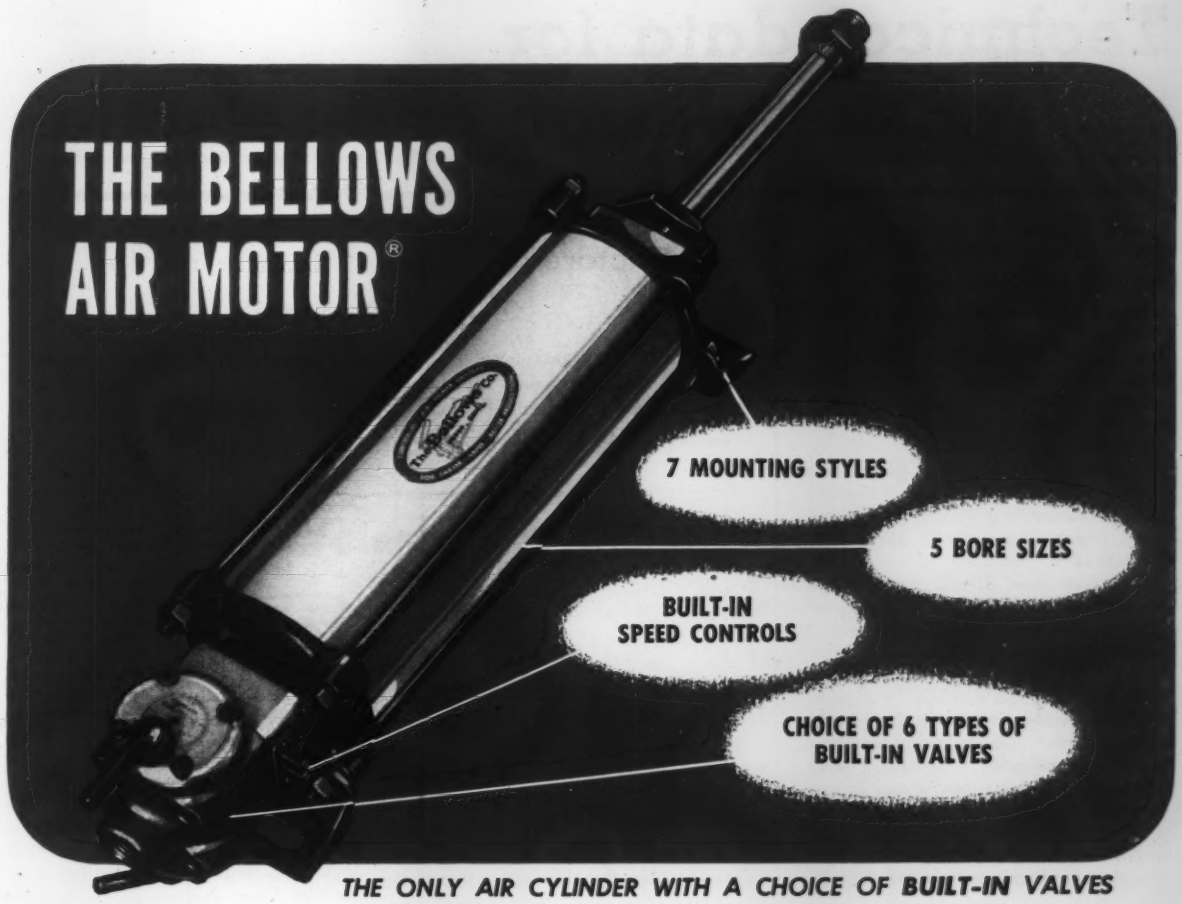
THE *Peerless Electric*® COMPANY

FANS · BLOWERS · MOTORS

1520 W. MARKET ST. · WARREN, OHIO

Circle 479 on Page 19

THE BELLOWS AIR MOTOR®



THE ONLY AIR CYLINDER WITH A CHOICE OF BUILT-IN VALVES

In designing for air operation, the engineer can choose the method of valving he prefers—and still have all the advantages of integral valve and cylinder construction.

Six different built-in valve arrangements give the engineer every latitude in pneumatic design.

If he prefers to use 8-12 volt electrical control with its simplified wiring, Bellows has it. If he prefers to use 115 volt control and JIC standards, Bellows has it. If he requires low or high voltage explosion-proof control, Bellows has it. Should his design require full pneumatic control, Bellows has it. Or should he wish to control his pneumatic circuits manually or through mechanical linkage or cams, Bellows has it.

Unlike conventional air cylinders which require separate remote directional and speed control valves and dual piping, the Bellows Air Motor is a complete power unit with directional valve and dual speed control valves built-in as an integral part of the unit. Only one air connection, which can be made with flexible hose, is required.

Integral valve and cylinder construction means quick response, more positive response, more precise control and more economical operation.

The Bellows Air Motor is made in five bore sizes: 1¼", 1¾", 2½", 3⅝", and 4½", and in any stroke length.

***WRITE FOR THIS BULLETIN* TODAY!**

Four-color, 20-page bulletin describes the complete line of Bellows Air Motors. Free on request. Address Dept. MD 1159, The Bellows Co., Akron 9, Ohio.

627-C

The Bellows Co.

DIVISION OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)

AKRON 9, OHIO

OTHER INDUSTRIAL DIVISIONS OF IBEC: Sinclair-Collins Valve Co., Valvair, Akron, Ohio • V. D. Anderson Co., Cleveland, Ohio

Circle 480 on Page 19

Technical data for gasket design and selection

How to get better sealing at no extra cost in fiber sheet gasket applications

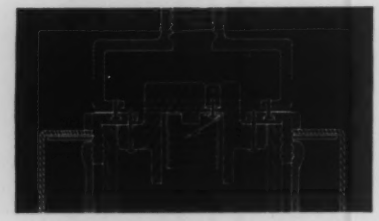
Economy is among the most important design objectives, whether it be an opportunity to reduce costs or a way to improve performance at no increase in price.

A new beater-saturated gasket material—Accopac N-852—is delivering such economy in a variety of applications where conventional plant fiber gaskets have been used.

In every case, N-852 was used at no increase in cost, and in many instances, this new material delivered a substantial bonus in better performance.

Accopac N-852 is made by a process pioneered and patented by Armstrong. In this process, cellulose fibers are combined with a synthetic latex binder and formed into dense, homogeneous sheets of unusual uniformity.

The binder in N-852 cannot be volatilized or extracted in any recommended application. As a result, gaskets cut from this new material will not shrink in use or in storage.



The efficiency of this vapor-tight light fixture was reduced when binder in a conventional plant fiber gasket volatilized and condensed inside globe. The non-extractable binder in N-852 helps eliminate problems of this type.

Accopac N-852 is recommended for any sealing job where glue-glycerine saturated materials are now being used. Typical applications are in caps for gasoline tanks and radiators, master cylinders for brakes, gear case covers, and hand hole covers.

N-852 is one of several cellulose-fiber and asbestos fiber materials in the Armstrong Accopac line. These materials can be obtained in sheets, rolls, ribbon or die cut parts; and they are available (as are all other Armstrong Gasket materials) through Armstrong approved gasket fabricators all over the country.

Factors to consider in determining gasket thickness

The thickness of a gasket material can affect its sealability, and this factor should be considered while a joint is in the design stage.

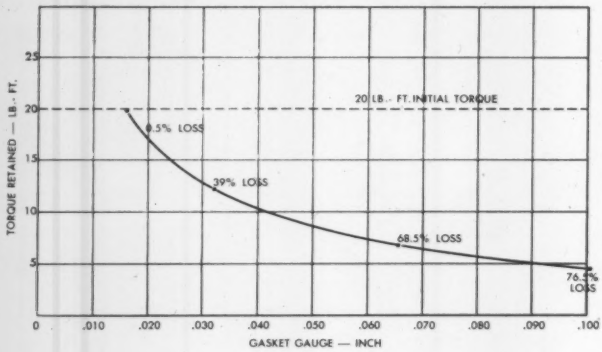
A general (but not unqualified) rule is to use the thinnest gasket that will seal the joint. Aside from the obvious benefit of economy, research by Armstrong engineers discloses that thin-gauge gaskets also offer certain mechanical advantages.

One of these is better torque retention. A gasket's ability to retain bolt torque increases as its thickness decreases.

This is illustrated by the curve reproduced above. Note that a gasket .015″ thick retains all but ½ of 1% of the initial bolt torque, while a gasket twice as thick retains only 60%. Torque retention decreases further as gasket thickness increases.

Less extrusion is another advantage obtained with thin gaskets. This is particularly true with straight rubber or the harder cork-and-rubber gasket materials.

There are, of course, factors that limit the use of thin gaskets. These stem from such things as non-parallel flanges, or flanges that bend or bow under bolt loads.



In this test, four gauges of one beater-saturated asbestos fiber gasket material were put in steel flanges and bolts torqued to 20 lb-ft. The flanges were heated at 300° F. for 18 hours, and retained torque was measured while flanges were hot.

For example, if a gasket cannot be compressed more than the cumulative deviations from perfect parallelism of the two flange surfaces, a seal cannot be obtained. Similarly, if the design of the joint permits flange bowing between bolts, leaks will result. In both cases, one remedy is to increase the gasket thickness.

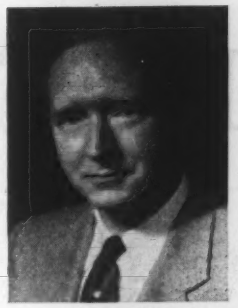
Gasket thickness is only one of many factors in gasket engineering that are under continuous study at the Armstrong Research and Development Center. Much detailed information on this work is contained in the Armstrong Gasket Design Manual. Write for your copy today.

For your copy of the Armstrong Gasket Design Manual, write to Armstrong Cork Company, Industrial Division, 7111 Dean St., Lancaster, Pa.

Armstrong GASKET MATERIALS

. . . used wherever performance counts

MACHINE DESIGN
November 26, 1959



Tolerance or Indignation?

TOLERANCE, in engineering, is generally thought of as an acceptable deviation from perfection. Tolerance of human conduct might be similarly described, though the limits are less definitely prescribed. The law takes care of some limits; but many others, not so governed, can have an effect on performance of the human community more devastating than some illegal acts.

For instance, to many people the revelation of deception in so-called quiz programs wasn't too disturbing. Millions of people were well entertained over a long period of time, and nobody seems to have been hurt, so runs the argument.

What would be the reaction if it should turn out that the World Series games had been rehearsed and the outcome preplanned? Pretty violent, wouldn't you expect? Yet if the quiz program deception is accepted complacently, it would not be a huge step to the next type of deception—the wholesale "fixing" of sports events.

Each step in the breakdown of ethics seems minor—not worth a big fuss. Yet the snowball effect has broken mighty empires. Look at that amiable practice known as the goof-off. A recent survey showed that the work force in a leading defense plant was productively occupied only 63 per cent of the so-called work day. Don't blame the "workers" entirely, either. Featherbedding—official and unofficial—is often condoned by management.

Yet the foregoing statistics tell us that the average worker in that plant, every eight-hour day, accepts pay for three hours of nonproduction. Why should such a man object to someone else accepting a reward for seeming to be smarter than he actually is? The argument applies in reverse, too.

Tolerance has its place. But tolerance has no meaning if the limits are boundless. Somewhere along the line tolerance must be supplanted by indignation.

Colin Carmichael

EDITOR

Reliability

A manufacturer who fails to exercise reasonable care in the manufacture of a chattel which, unless carefully made, he should recognize as involving an unreasonable risk of causing substantial bodily harm to those who lawfully use it for a purpose for which it is manufactured and to those whom the supplier should expect to be in the vicinity of its probable use, is subject to liability for bodily harm caused to them by its lawful use in a manner and for a purpose for which it is manufactured.

The precaution necessary to comply with the standard of reasonable care varies with the danger involved. Consequently the character of harm likely to result from the failure to exercise care in manufacture affects the question as to what is reasonable care. It is reasonable to require those who make or assemble automobiles to subject the raw material, or parts, procured from even reputable manufacturers, to inspections and tests which it would be obviously unreasonable to require of a product which, although defective, is unlikely to cause more than some comparatively slight, though still substantial, harm to those who use it. A garment maker is not required to subject the finished garment to anything like so minute an inspection for the purpose of discovering whether a basting needle has not been left in a seam as is required of the maker of an automobile or of high-speed machinery or of electrical devices, in which the slightest inaccuracy may involve danger of death.

A manufacturer is required to exercise reasonable care in manufacturing any article which, if carelessly manufactured, is likely to cause more than trivial harm to those who use it in the manner for which it is manufactured. The particulars in which reasonable care is usually necessary for protection of those whose safety depends upon the character of chattels are, (1) the adoption of a formula or plan which, if properly followed, will produce an article safe for the use for which it is sold, (2) the selection of material and parts to be incorporated in the finished article, (3) the fabrication of the article by every member of the operative staff no matter how high or low his position therein, (4) making such inspections and tests during the course of manufacture and after the article is completed as the manufacturer should recognize as reasonably necessary to secure the production of a safe article, and (5) the packing of the article so as to be safe for those who must be expected to unpack it.

The exercise of reasonable care in selecting raw material and parts to be incorporated in the finished article usually requires something more than a mere inspection of the material and parts. A manufacturer should have sufficient technical knowledge to select such a type of material that its use will secure a safe finished product. So too, a manufacturer who incorporates a part made by another manufacturer into his finished product should exercise reasonable care to ascertain not only the material out of which the part is made but also the plan under which it is made. He must have sufficient technical knowledge to form a reasonably accurate judgment as to whether a part made under such a plan and of such material is or is not such as to secure a safe finished product. The part is of his own selection, and it is reasonable for the users of the product to rely not only upon a careful inspection but sufficient technical knowledge to make a careful inspection valuable in securing an article safe for use. In all of these particulars the amount of care which the manufacturer must exercise is proportionate to the extent of the risk involved in using the article if manufactured without the exercise of these precautions. Where, as in the case of an automobile or high-speed machinery or high-voltage electrical devices, there is danger of serious bodily harm or death unless the article is substantially perfect, it is reasonable to require the manufacturer to exercise almost meticulous precautions in all of these particulars in order to secure substantial perfection. On the other hand, it would be ridiculous to demand equal care of the manufacturer of an article which, no matter how imperfect, is unlikely to do more than some comparatively trivial harm to those who use it.

It is not necessary that the manufacturer should expect his product to be used in the form in which it is delivered to his vendee. A manufacturer of parts to be incorporated in the product of his vendee or others is subject to liability under the rule stated in this Section, if they are so negligently made as to render the products in which they are incorporated unreasonably dangerous for use. So too, a manufacturer of raw material made and sold to be used in the fabrication of particular articles which will be dangerous for use unless the material is carefully made, is subject to liability if he fails to exercise reasonable care in its manufacture.

—From *Restatement of the Law of Torts*, American Law Institute Publishers, St. Paul, Minn., 1934, Chapter 14, Section 395.

or Liability?

ALBERT WOODRUFF GRAY
Forest Hills, New York

Here are the standards set up by the courts for measuring a manufacturers' legal responsibility for safe operation of his product.

WHEN a product involves danger to "life and limb" in its use, the manufacturer is under a legal duty to use "reasonable care" in making it, or to warn others of the hazards in its operation. This "unwritten" obligation applies to components as well as to complete assemblies. Standards for measuring the extent of a manufacturer's responsibility have been well established by the courts.

ON a good road in New York, two men were travelling in an automobile at a speed of about 8 mph when the spokes of the left rear wheel broke. The wheel collapsed and one of the occupants was thrown from the car and injured.

This car had been sold to the victim of the accident by a dealer who bought it from the manufacturer. The wheels had been supplied the automobile manufacturer by a reputable dealer. However, no examination had been made of them. The manufacturer simply added the necessary iron parts and primed the wheels with a coat of paint.

Suit was brought by the owner of this car for damages, not from the dealer who had sold him the car, but from the manufacturer. Judgment was awarded the car owner by the lower court on the ground that the manufacturer was negligent. On an appeal by the manufacturer, the judgement was affirmed by the appellate court:[1]

"We hold that under the circumstances the manufacturer owed a duty to all purchasers of its automobiles to make a reasonable inspection and test to ascertain whether the wheels purchased and put in use by it were reasonably fit for the purpose for which it used them and, if it fails to exercise care in that respect, that it is responsible for any defect which would have been discovered by such reasonable inspection and test."

Again the manufacturer appealed, this time to the Court of Appeals of that state. The decision that followed has served to establish firmly the responsi-

[1]References are tabulated at end of article.

Reasonable care consists among other things in making such inspections and tests . . . as the manufacturer should recognize as reasonably necessary to secure the production of a safe article.

—MICHIGAN APPELLATE COURT

bility of manufacturers to both immediate and remote purchasers and users for product defects due to negligence.

In its celebrated statement of this law, the court said: "If the nature of a thing is such that it is reasonably certain to place life and limb in peril when negligently made, it is then a thing of danger. Its nature gives warning of the consequences to be expected.

"If to the element of danger there is added knowledge that the thing will be used by persons other than the purchaser, and used without new tests, then, irrespective of contract, the manufacturer of this thing of danger is under a duty to make it carefully. That is as far as we are required to go for the decision of this case.

"There must be knowledge of a danger, not merely possible, but probable. It is possible to use almost anything in a way that will make it dangerous if defective. That is not enough to charge the manufacturer with a duty independent of his contract.

"Whether a given thing is dangerous may be sometimes a question for the court and sometimes a question for the jury. There must also be knowledge that in the usual course of events the danger will be shared by others than the buyer. Such knowledge may often be inferred from the nature of the transaction. But it is possible that even knowledge of the danger and of the use will not always be enough.

"The proximity or remoteness of the relation is a factor to be considered. We are dealing now with the liability of the manufacturer of the finished product, who puts it on the market to be used without inspection by his customers. If he is negligent, where danger is to be foreseen, a liability will follow."

Then, in its conclusion, the court added a summary of this law that has since been followed generally by all the courts of the country in the succeeding forty years. "We think the manufacturer was not absolved from a duty of inspection because it bought the wheels from a reputable manufacturer. It was not merely a dealer in automobiles. It was responsible for the finished product. It was not at liberty to put the finished product on the market without subjecting the component parts to ordinary and simple tests."[2]

SEVERAL years later, this rule of law was somewhat modified by the Massachusetts Supreme Court. In supplementing the previous New York decision the court stated,

"In principle a manufacturer or other person knowing or controlling a thing that is dangerous in its nature or is in a dangerous condition either to his knowledge or as a result of his want of reasonable care in manufacture or inspection, who deals with or disposes of that thing in a way that he foresees or in the exercise of reasonable care ought to foresee will probably carry that thing into contact with some person, known or unknown, who will probably be ignorant of the danger, owes a legal duty to every such person to use reasonable care to prevent injury to him."

The court went on to add, "Of course there are limits to that principle. One is that where the person injured comes into contact with the dangerous thing only by trespass, the right of the owner to use his property as he pleases short of maintaining a nuisance, precludes any duty of care to any person even though his presence on the property could have been foreseen.

"Another is that the manufacturer may be absolved from blame because of a justified reliance upon the inspection by a middleman. Still another is that the casual relation of a manufacturer's negligence to the injury may be broken by the intervention of a superseding cause such as some negligence or fault of another whereby the manufacturer's negligence ceases to be the proximate cause of the injury."[3]

THE duty of "reasonable care" placed on manufacturers is not limited to just product defects. When a manufactured article, potentially dangerous, is put on the market, the manufacturer must warn prospective purchasers or users of these dangers or he may be liable for consequent damages.

At a trade school in Massachusetts, a fourteen year old boy was given a grinding wheel to sharpen a rag cutter. Tapped, the wheel gave a clear ring. No defects were visible. However, the wheel was limited for safe use to a maximum speed of 5729 rpm. No notice of this limitation on the wheel or corresponding caution in its use was given.

When the wheel reached a speed of 10,000 rpm, it burst. A piece of the wheel struck the boy in the

We are dealing now with the liability of the manufacturer of the finished product, who puts it on the market to be used without inspection by his customers. If he is negligent, where danger is to be foreseen, a liability will follow.

—New York Appellate Court

eye. On the wheel were labels with blank spaces to be filled in with both test and recommended speeds but neither of these blanks had been used by the manufacturer.

In its decision, imposing on the manufacturer a liability for this injury to the boy, the court asserted, "If the manufacturer owes a duty to use due care in making his products, he owes also a companion duty to warn of the latent limitations of even a perfectly made article, the use of which however, is dangerous if the user is ignorant of these limitations and the manufacturer has no reason to believe that he will recognize the danger."[4]

WHILE being mounted on a truck wheel, a defective tire exploded, injuring a service station operator. The tire had been manufactured at Waco, Texas, and sold to a dealer who resold it to a furniture company. It was held in a warehouse until just before the accident.

"The manufacturer," said the court in its decision of the suit that followed, "is liable when he fails to exercise reasonable care in the manufacture of a chattel which unless carefully made, involves unreasonable risk to those who lawfully use it in a manner and for a purpose for which it was manufactured."[5]

IN the application of these rules, the courts have also set certain limits. In Michigan, suit was brought against an aircraft manufacturer. While in the air, the engine of a plane suddenly started to run rough, oil sprayed over the windshield, and the engine froze, forcing a crash landing and consequent damage.

Bringing suit, the owner of the plane charged that the manufacturer had installed a latently defective connecting rod without adequate inspection before assembly.

The rod had been purchased from a forging company in Michigan and was made of steel bought from a mill in Pennsylvania. After the rod had been assembled, the engine was sold to the airplane manufacturer. The purchaser of the plane contended that the connecting rod failed because of so-called inclusion pits which could have been detected by either Magnaflux or X-ray inspection.

Reversing a judgment against the manufacturer by the lower court, the Michigan court said, "The obligation to inspect must vary with the nature of the thing inspected. The more probable the danger the greater the need of caution. In the instant case the defect could not have been discovered by reasonable inspection. There was therefore a duty to use reasonable care.

"Reasonable care consists among other things in making such inspections and tests during the course of manufacture and after the article is completed as the manufacturer should recognize as reasonably necessary to secure the production of a safe article."[6]

IN the eyes of the courts, the liability for defective manufacture applies to any manufacturer who contributes to the finished product. This viewpoint is clearly shown in the decision of a recent California controversy.

At work 90 ft from the ground on an oil derrick, an employee wore a safety belt. Attached to the back of this belt was a D-shaped metal ring which was secured to a rope. The rope was anchored to the derrick. The workman slipped, the ring failed to hold, and the man was killed by his fall.

In the court suit that followed, action was brought against the manufacturer of the ring for the death of the workman. In his defense, the manufacturer contended that he could not be held for negligence because he supplied only a part of the assembly and such liability rested entirely on the maker of the finished product.

"There emerges," said the court, "a broad rule of liability applicable to the manufacturer of any chattel, whether it be component part or an assembled entity. Stated with reference to the facts of this particular case it is, if either manufacturer was negligent in circumstances pointing to an unreasonable risk of serious bodily injury to one in this workman's position, liability may follow although privity is lacking."[7]

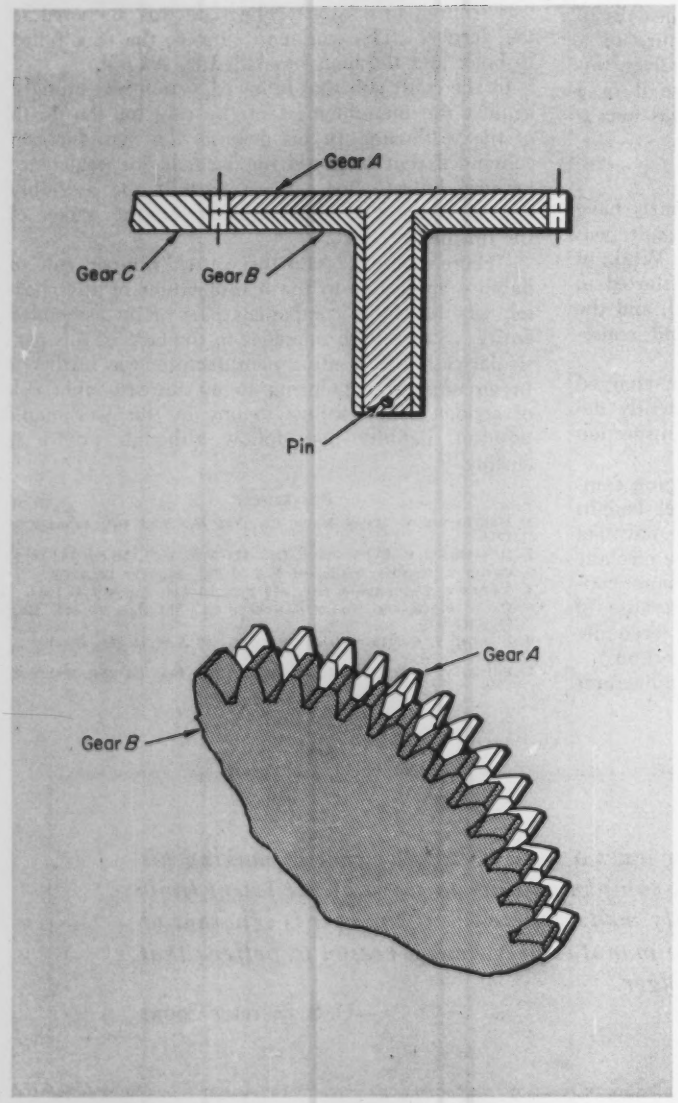
REFERENCES

1. MacPherson v. Buick Motor Co., 145 *N.Y.S.2d* 462, January 7, 1914.
2. MacPherson v. Buick Motor Co., 111 *N.E.* 1050, March 14, 1916.
3. Carter v. Yardley & Co., 64 *N.E.2d* 693, January 17, 1946.
4. Tomas v. De Sanno & Son, 209 *Fed.* 2d 544, January 4, 1954.
5. Hewitt v. General Tire and Rubber Co., 284 *Pac.* 2d 471, May 24, 1955.
6. Livesley v. Continental Motors Corp., 49 *N.W.2d* 385, October 2, 1951.
7. Edison v. Lewis Manufacturing Co., 336 *Pac.* 2d 286, March 6, 1959.

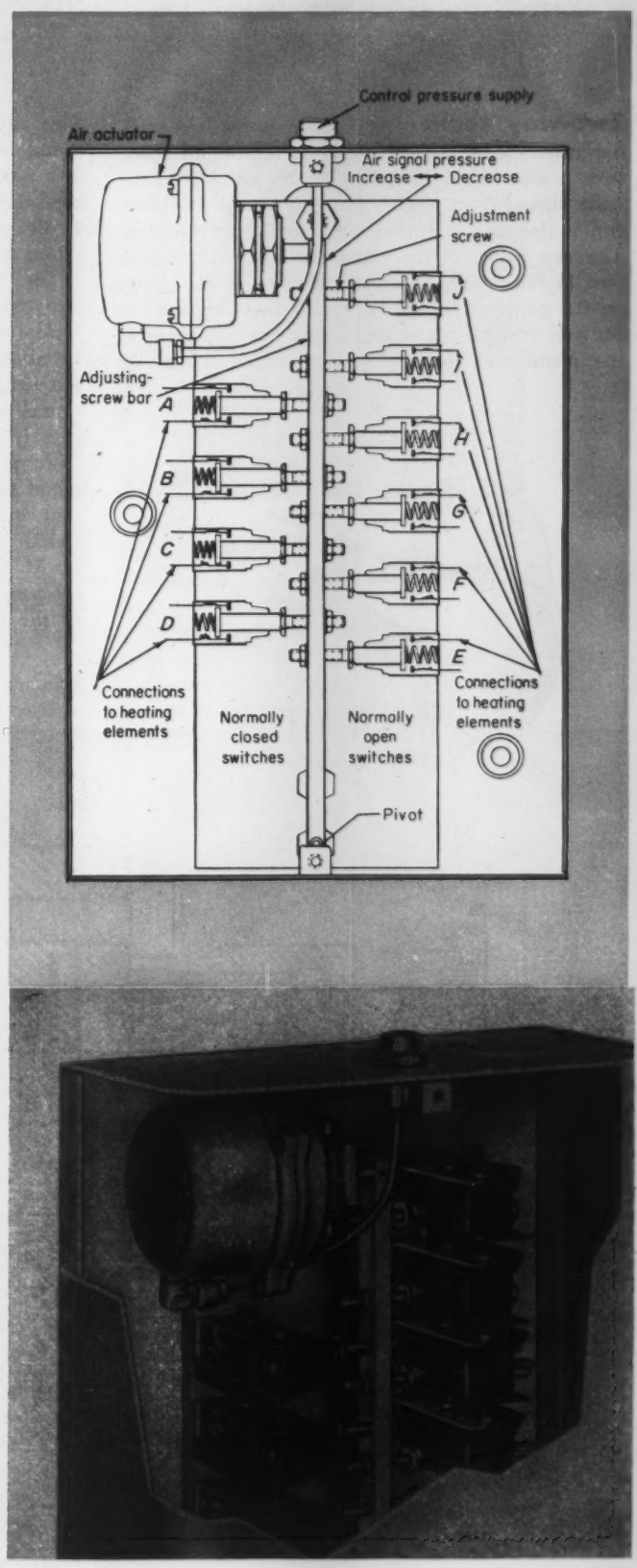
If the manufacturer owes a duty to use due care in making his products, he owes also a companion duty to warn of the latent limitations of even a perfectly made article . . . if the user is ignorant of these limitations and the manufacturer has no reason to believe that he will recognize the danger.

—U. S. DISTRICT COURT

scanning the field for *ideas*

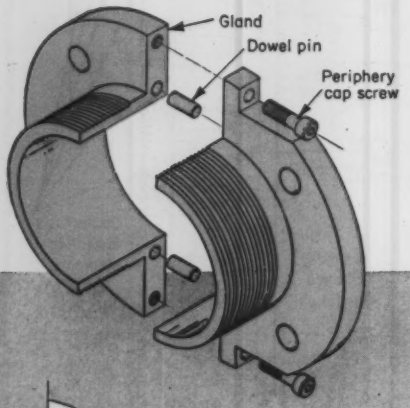


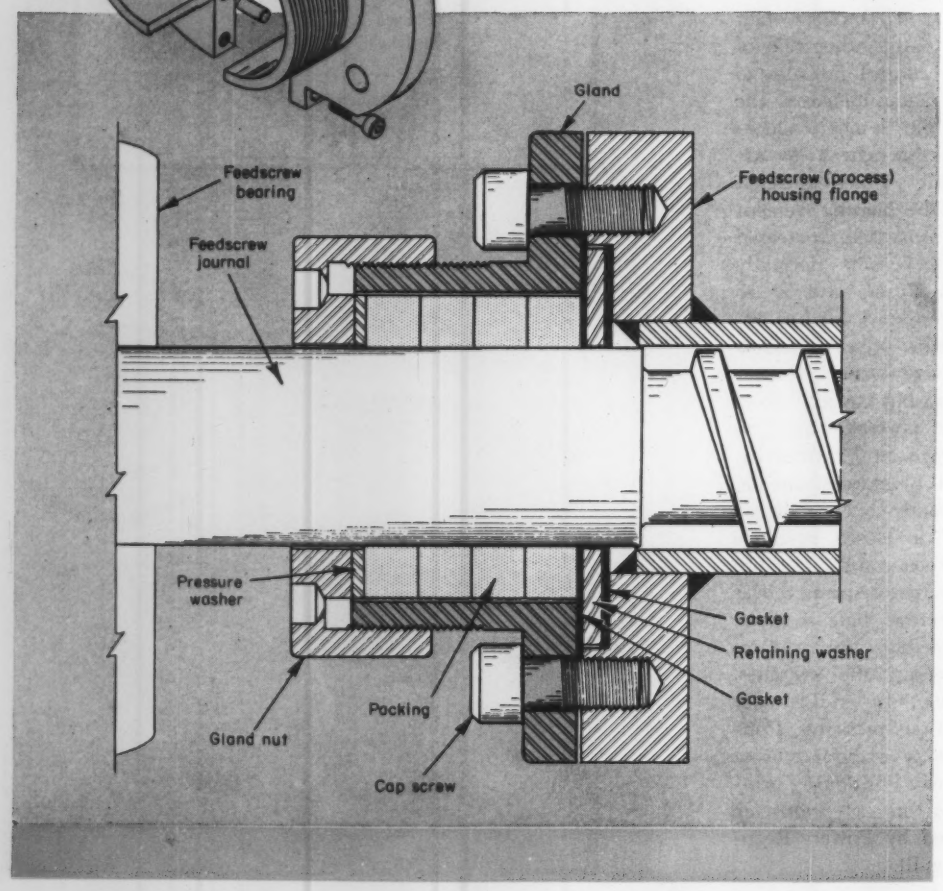
Torsion-bar twist on a split gear eliminates backlash in gear train. The torsion bar arrangement consists of a spur gear, *A*, integrally attached to a solid shaft and a second spur gear, *B*, integrally attached to a tubular shaft. Both gears have the same diametral pitch and number of teeth. The solid shaft of gear *A* fits loosely in the tubular shaft of gear *B* and the two shafts are secured together at the end remote from the gears. The teeth of gear *A* are displaced with respect to the teeth of gear *B* prior to securing the shafts. The extent of the displacement depends on the amount of wedging force desired. In operation, gear *C*, which is equal in width to the combined widths of the split gears, is meshed with the antibacklash gears, *A* and *B*. Thus, as the teeth are forced into alignment, the twist in the shafts imposes pressure on both sides of gear *C*. Torsion-bar principle employed in a patented antibacklash gear device developed by Raymond A. Gaither, Pendelton, Ind.

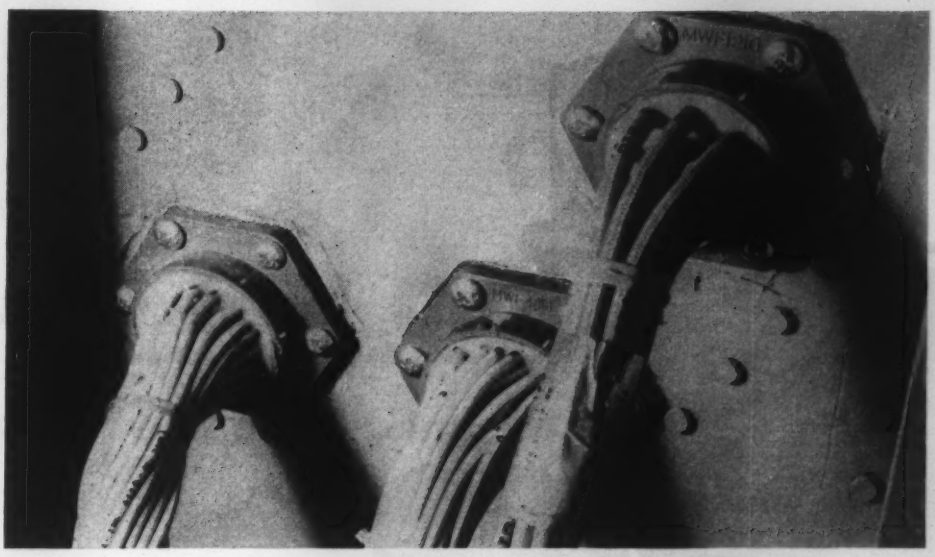


Pneumatically positioned pivot arm actuates a series of switches in sequence to control output of electric-resistance heating elements. A group of normally closed switches (*A* through *D*) is attached to one side of a pivoted adjusting-screw bar, and a set of normally open switches (*E* through *J*) is attached to the other side of the bar. When control pressure to a pneumatic actuator increases, the adjusting-screw bar is moved clockwise, permitting switch *A* to assume a normally closed position and energizing the heating element connected to this switch. Increased control pressure permits normally closed switches *B*, *C*, and *D* to close in that order. A further increase in control pressure moves the adjusting-screw bar further (clockwise), causing switch *E* to move from the normally open to the closed position. Still further increase in control pressure moves the remaining normally open switches (*F* through *J*) to closed positions in sequence. When control pressure decreases, the actuator spring moves the adjusting-screw bar counterclockwise, reversing the control cycle and opening the switches. Each switch can be individually adjusted for various pressures. Control is provided by a thermostat or pressure regulator. Positioning principle employed in a multi-step switch developed by Powers Regulator Co., Skokie, Ill.

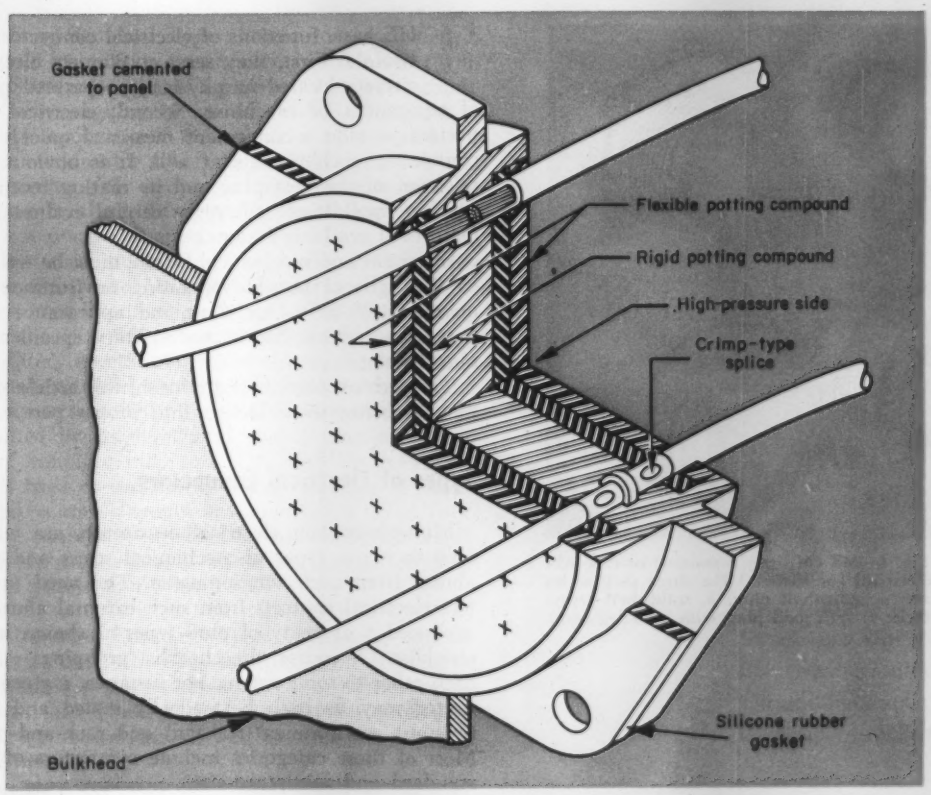
Two-way sealing of feed screw for fine powder conveyor is accomplished in minimum space with a split gland. One end of the gland is externally threaded to receive the gland nut; the other end is flanged for bolting to a feed-screw housing. The two halves of the gland are aligned by dowel pins in the flange, and are held together by screws on the periphery of the flange. A retaining washer between two gaskets is held under pressure between the gland and the feed-screw housing flange by four cap screws. During packing installation, the gland nut and pressure washer are moved to the left extremity of the feed-screw journal while the retaining washer, between two gaskets, is moved to the right extremity. The gland section with the dowel pins attached is mounted on the lower side of the feed-screw housing and held in place by two cap screws. This gland section forms a receptacle for the bottom of the journal and facilitates installation of the packing. After the packing rings are installed, the upper half of the gland is positioned to engage the dowel pins and the gland section is secured with the cap screws. The two remaining cap screws are installed in the flange, the gland nut is threaded over the gland, and all screws and nuts are torqued to accomplish the desired radial and axial seal. Split-gland seal developed by M. Collier for the feed-screw mechanism of the reactors at the Portsmouth Gaseous Diffusion Plant of the Goodyear Atomic Corp., Portsmouth, Ohio.

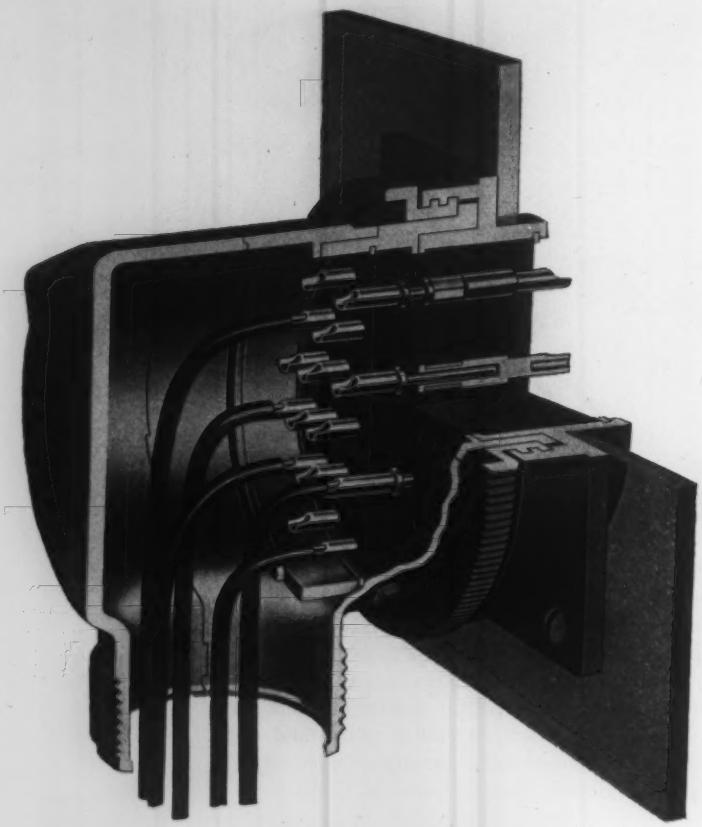






Crimped splices prevent air leakage around multiple-wire electrical connections in wall of high-pressure vessels. The wires are crimped to silver-plated copper alloy links which conduct current, but seal against air leakage around wire strands. After the wires are placed through a glass-filled panel, they are externally sealed with two layers of potting compound on either side of the glass-filled panel. The outer layer of potting is flexible to permit flexing of leads. In installation, the completed panel is cemented to a silicone rubber gasket and the whole unit is cemented to the vessel wall. Crimped-splice principle employed in aircraft cabin sealing device developed by Burndy Corp., Norwalk, Conn.





A designer's guide

ROBERT L. EKLUND
Cannon Electric Co.
Los Angeles, Calif.

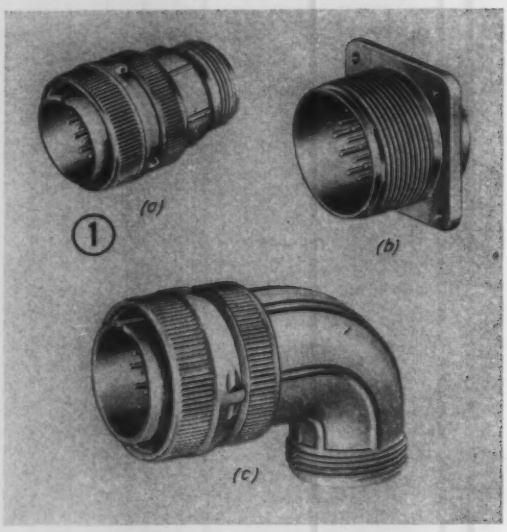


Fig. 1—MS (Military Standard) or type AN electrical connectors. The three shell styles are: *a*, split-shell plug; *b*, solid-shell receptacle; *c*, split-shell plug with a 90-deg bend.

THE basic functions of electrical connectors are twofold. First, they serve to connect electrical circuits located in physically separated pieces of equipment or machines. Second, electrical connectors provide a convenient means of quickly disconnecting such circuits at will. It is obvious that selection of the best plug and its mating receptacle for any application requires a careful evaluation of features of available designs.

Electrical and mechanical factors must be weighed in the light of possible operating environments of an electrical connector. Cost and appearance often enter the picture. Sometimes military specifications must be met.

Through an organized approach, this article shows how to bring these factors into proper perspective.

Types of Electrical Connectors

Multiple-contact electrical connectors are vulnerable to many types of mechanical stress and other abuses from their environments. The need to protect electrical contacts from such external abuse has produced a diversity of plug types as shown in the checklist. Of course, the checklist groupings overlap each other to some extent. For instance, a given connector may be both hermetically sealed and heat-resistant, environment-resistant and rack-and-panel. Most of these categories include connectors of both standard and miniature sizes.

for selecting

Electrical Connectors

for signal and power circuits

Military Standard Types: If electrical equipment is designed for military use, it may require a MS (Military Standard) type of connector. However, conditions often require the use of non-MS connectors in military applications. If there is a valid reason for using a connector which is not MS-approved, i.e., configuration of equipment or environmental requirements, the Military will generally approve the use of a nonspecification connector.

The general-purpose AN type connector, as well as the MS-E and MS-R types, conform to Defense Department Specification MIL-C-5015 (D revision). Since the term MS refers to all connectors covered by military specifications, the old nomenclature AN has been retained to designate this general-purpose MS connector. This Type AN connector can be identified by its cylindrical shape, standard screw-thread coupling nut, and olive-drab finish, Fig. 1. It has fixed contacts with a large number of standardized contact layouts available. This is an inexpensive connector, intended for use where standardization is required and where no special environmental problems are involved.

Environment-Resistant Types: Where a connector must resist vibration, moisture, and changes in atmospheric pressure, environment-resistant designs are available. These include several types covered by military specifications, as well as some nonspecification lines.

The most common environment-resistant connec-

Selection Factors

Connector Types

- Military standard
- Environment resistant
- Hermetically sealed
- Heat resistant
- Flame resistant
- Rack and panel
- Printed circuit
- RF coaxial
- Audio and video
- Power and battery
- Umbilical
- Special purpose

Electromechanical Factors

- Number of contacts
- Contact size and spacing
- Style of contacts
- Insulation material
- Mounting space
- Coupling method

Environmental Factors

- Temperature
- Moisture and humidity
- High altitude
- Shock and vibration
- Corrosive conditions
- Oil and hydraulic fluids
- Destructive radiation

Fig. 2 — Environment-resistant electrical plugs. The unit in *a* is designed with a conventional cable clamp. A new design, *b*, uses a grommet-type seal to save weight and space.

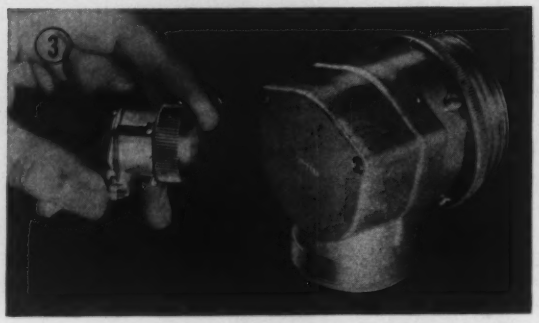


Fig. 3 — Miniature environment-resistant, Type KM plug, *a*, compared to a standard Type K plug. Designed to USAF specification MIL-C-25955, the miniature plug is sealed against moisture and atmospheric pressure changes, permitting its use at extreme altitudes.

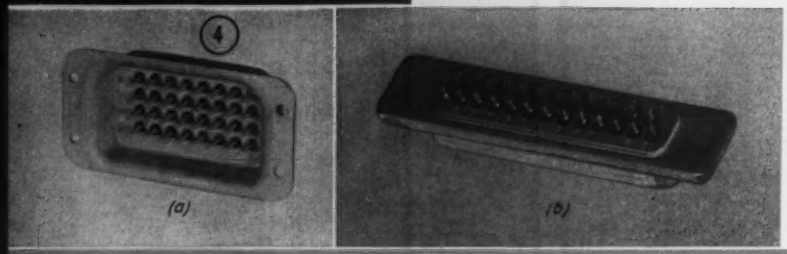


Fig. 4—Hermetically sealed receptacles designed for rack-and-panel applications. In *a* is the front view of a 32-pin unit. In *b* is the rear view of a miniature receptacle which shows the eyelet-type wire terminals.

tors now in service are the MS-E and the MS-R, Fig. 2, conforming to MIL-C-5051D. The MS-E was called out in previous revisions of the spec, and the current revision states that it may continue to be used in existing equipment. For new designs, however, the new MS-R is to be used.

Like the general-purpose AN series, MS-E and MS-R connectors are cylindrical in shape with threaded coupling nuts. Shells are aluminum with olive drab finish. Both the MS-E and MS-R have resilient insulators to absorb vibration, and they are sealed against moisture and atmospheric pressure variations. Their size range is identical to that of the general-purpose AN series, and the same standard contact layouts are used.

The MS-E design has traditionally included an external cable clamp, built onto the endbell of the connector, for cable support. The MS-R, and some MS-E designs, use a resilient grommet for clamping and sealing at the rear of the connector in place of the cable clamp, Fig. 2. This design approach produces a shorter, lighter connector.

For aircraft equipment, miniature plugs with environment-resistant features similar to standard-sized plugs have been developed. Several of these miniatures should be considered as MS plugs, since they are designed to US Air Force Specifications. The most important of the miniature and environmental specs now in effect are: 1. MIL-C-25955 (general-purpose, cylindrical, Fig. 3). 2. MIL-C-26500 (high-temperature, cylindrical). 3. MIL-C-26518 (high-temperature, rack/panel). All of these designs use crimp-type, snap-in removable contacts.

A number of plug types not covered by military specifications are environment-resistant, often to a degree which far exceeds military requirements.

Hermetically Sealed Types: When the plug is to be mounted on a sensitive instrument which must withstand extreme changes in pressure, hermetically sealed plugs, Fig. 4, should be selected. Beads of glass around the individual contacts provide the hermetic sealing. These beads are bonded to a steel header. The steel and the glass are so selected that their coefficients of expansion are nearly identical; thus temperature extremes will not break the seal.

Hermetically sealed receptacles are available to mate with all sizes of MS plugs, with contact arrangements matching standard MS patterns. In addition, there are hermetically sealed versions of most nonmilitary plug types.

Heat-Resistant and Flame-Resistant Types: Two specialized types of plugs have been developed to deal with problems arising from extreme heat: 1. The continuous-duty, heat-resistant plug, Fig. 5. 2. The sacrificial flame-barrier type plug, Fig. 6.

Continuous-duty, heat-resistant plugs are designed to operate in temperatures around 1000 F for indefinite periods of time, without damage to plug or associated circuits. The plug in Fig. 5 is designed with a stainless-steel shell, alumina ceramic insulator, and solid silver-alloy contacts. These plugs are often used in nuclear reactors, where a combination of heat and radiation is encountered.

Another type of plug, the sacrificial flame-resistant

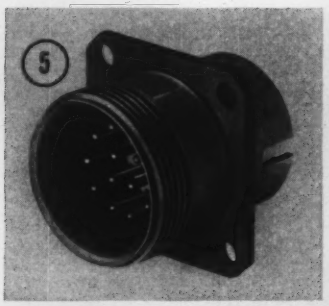


Fig. 5 — Heat-resistant plug designed for continuous operation in 1000 F ambients. It is designed with a stainless-steel shell, solid-silver contacts, and an alumina-ceramic insulator.

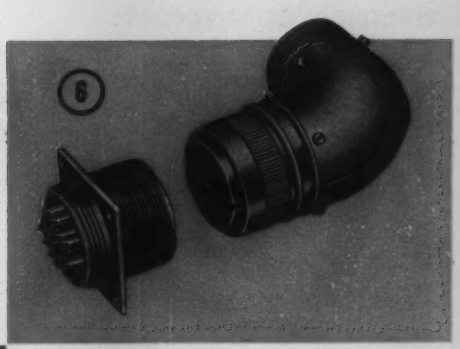


Fig. 6—Flame-resistant electrical connector designed with a 90-deg angle in the plug.

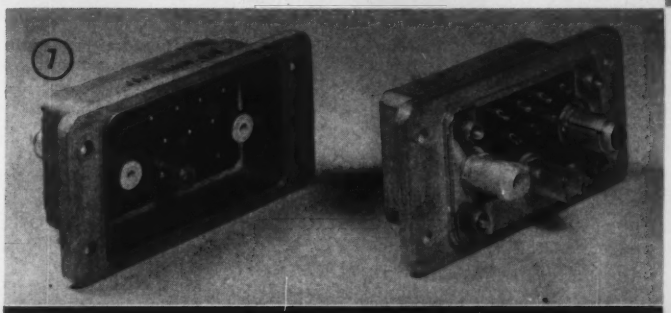


Fig. 7—Mating halves of rack-and-panel connector. Both standard and coaxial contacts are used in this insert arrangement.

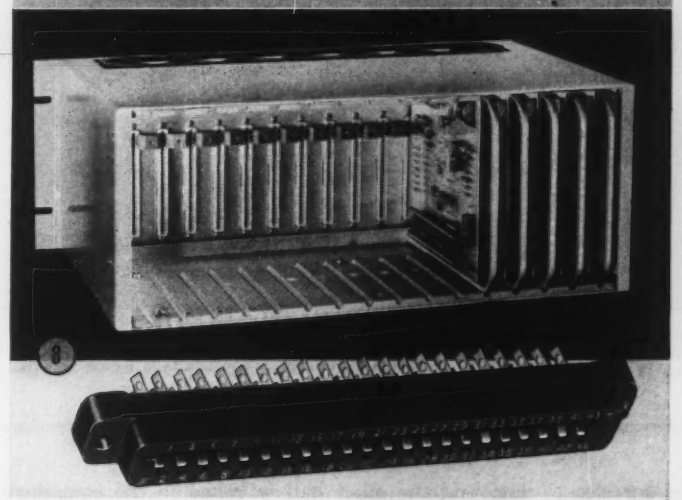


Fig. 8—Typical printed-circuit board receptacle and computer application. Designed to connect with boards having printed conductors on both sides, the receptacle has spring contacts on both sides of the opening.

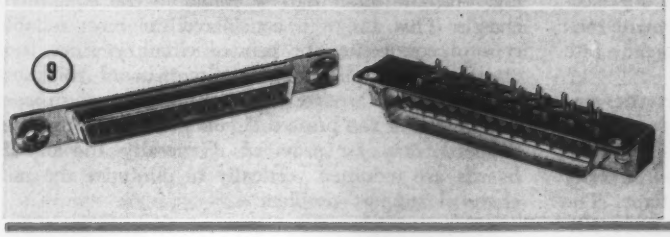


Fig. 9—Mating printed-circuit connector units. Receptacle at left is bolted to equipment chassis, and plug at right is attached to printed-circuit board by inserting pins on top of plug into holes in the board.

plug, was developed particularly to meet emergencies caused by fire in aircraft engines. It is also known as a "firewall" plug. The MS-K type, Fig. 6, conforming to class K of MIL-C-5015D, is often used in this application. It is required to operate (carry current and resist shorting) for 5 minutes at 2000 F, and to block the passage of flame through the plug for 20 minutes. These MS-K's, as well as the non-MS types designed for this application, usually use insulators of glass-filled melamine and shells of steel.

Rack-and-Panel Types: The terms rack/panel or rack-and-panel refer to the plug-and-receptacle mounting method. A wide variety of types—sealed and nonsealed, standard-size and miniature, cylindrical and rectangular—are included in this category.

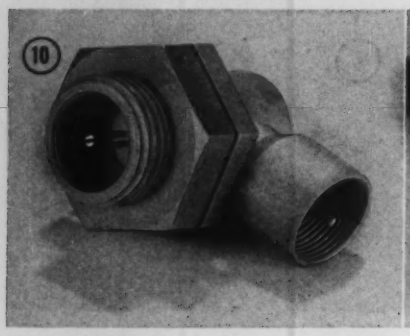


Fig. 10—Aluminum rf coaxial electrical connector.

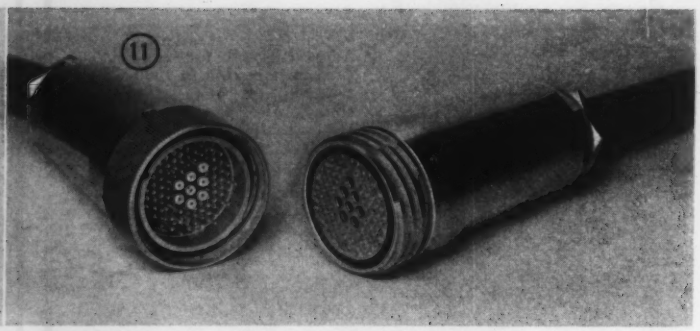


Fig. 11—Video connector for color television broadcasting equipment. Connector is designed with eight coaxial contacts for rf circuits and 83 standard contacts.

Fig. 12 — Typical audio-circuit connector.

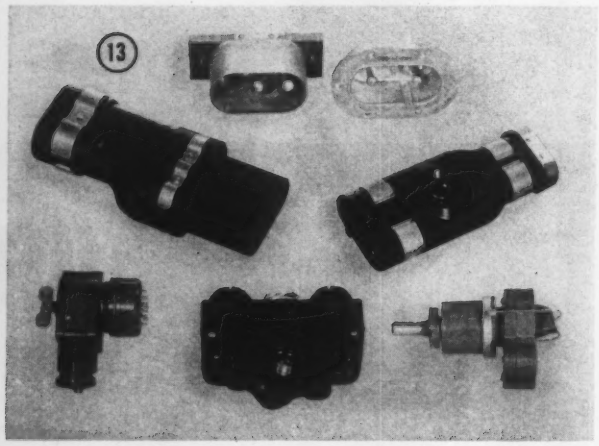


Fig. 13—Assorted types of battery and power plugs and receptacles.

Rack-and-panel connectors are designed for electrical connections made between an equipment rack and the removable panels or chassis which slide into the rack.

Half of the connector is mounted on the stationary rack and the other mating half on the removable panel.

Rack-and-panel connectors, Fig. 7, are usually rectangular rather than cylindrical in shape. The rectangular shape utilizes a small space more efficiently than a circular layout, and is simpler to polarize.

Printed-Circuit Types: Two principal types of connectors have been developed for quick-disconnect from printed-circuit boards. In one design, the circuit board itself serves as one half of the connector, Fig. 8. In another technique, one connector half is permanently affixed to the circuit board, Fig. 9.

The type shown in Fig. 9 is essentially a rack-and-panel installation. One connector half is permanently mounted on the circuit board by dip soldering, and the other half is bolted to the equipment chassis. This design is considered the most reliable type of connection for printed circuitry, since it is unaffected by variations in circuit-board thickness or by board warpage. The connector may support the weight of the printed-circuit unit, or mechanical supports may be provided. Generally the circuit boards are mounted vertically to minimize the mechanical support problem.

RF Coaxial Types: For connection and termination of radio-frequency transmission lines, ordinary connectors are unsuitable because of the excessive loss of radio-frequency energy. Special electrical connectors have been developed for rf applications, Fig. 10 and 11. These connectors are designed to minimize the energy losses in coaxial lines used for rf transmission.

Rf coaxial connectors have been classified by the ASESA (Armed Services Electro-Standards Agency), Fort Monmouth, N. J., into various series according to their function.

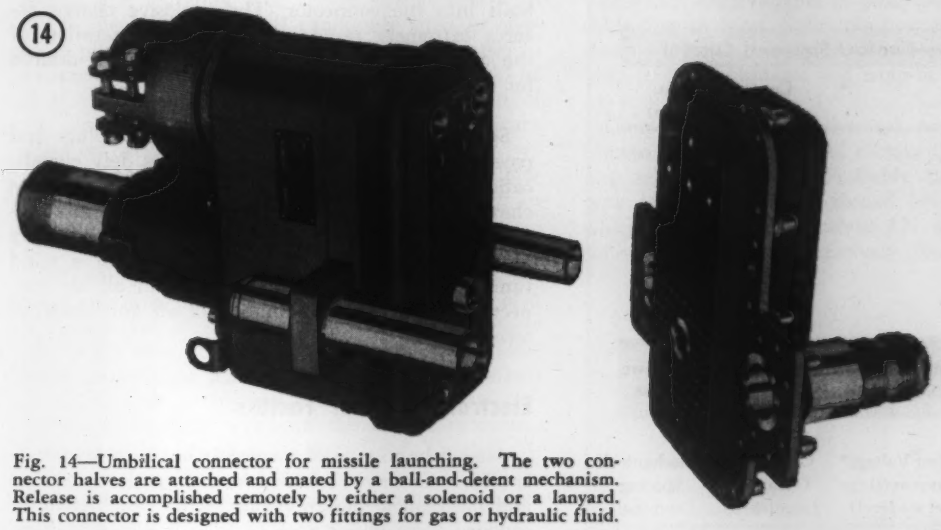


Fig. 14—Umbilical connector for missile launching. The two connector halves are attached and mated by a ball-and-detent mechanism. Release is accomplished remotely by either a solenoid or a lanyard. This connector is designed with two fittings for gas or hydraulic fluid.

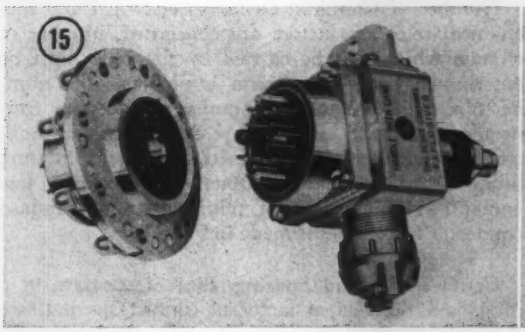


Fig. 15—Receptacle and plug for electrical disconnect in the Atlas nose cone. Disconnect is effected by an explosive squib in the plug.

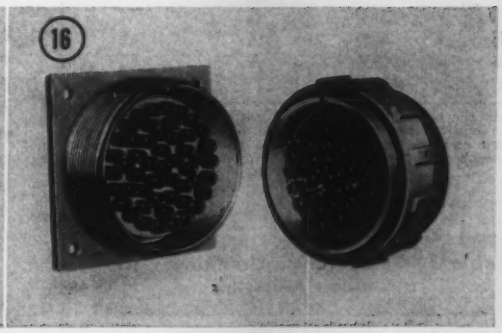


Fig. 16—Special-purpose plug and receptacle designed for air-pressure instrumentation on a wind tunnel at the California Institute of Technology.

Audio and Video Types: Audio-type connectors, Fig. 12, originally designed for use with plug-in microphones and other audio circuitry, have proved adaptable to instrumentation, home hi-fi, film studio equipment, and other applications where compact configuration, simple disconnect, smart appearance, low electrical noise level, and relatively few conductors are required.

Contact arrangements of three or four contacts are most common in audio plugs, although eight or more contacts can be obtained in some audio types.

Video plugs, Fig. 11, are designed specifically for plug-in to television cameras and associated equipment. They generally incorporate both coaxial and standard contacts within the same plug.

Power and Battery Types: It is convenient, and often necessary, to have a plug in the circuit between a battery, or power source, and the unit using the power. Heavy-duty plugs with large current-carrying capacity are required for these power and battery circuits.

Battery plugs and receptacles, Fig. 13, are sturdy and rugged to withstand severe service conditions. They are usually designed with heavy-duty shells of rubber or other resilient material. The most common contact arrangement is to use two power contacts having current ratings of about 165 to 1500 amperes each. A third contact is frequently added for a signal circuit; six contacts are not uncommon.

Umbilical Types: Missile launching requires special electrical connectors that carry many different types of circuits from ground installations to the missile via a single connector—a connector that can be quickly disconnected from a remote point. This type of connector, Fig. 14, is known as an umbilical —a name which suggests the resemblance between the single large cable leading to the missile and the human umbilical cord.

A similar type of connector, Fig. 15, is used for electrical disconnect between the stages of the missile. These multistage disconnect connectors are often actuated by an explosive charge, or squib, which is

Table 1—Contact Size and Current

Current (amp)	Contact-Size No. (same as wire gage)
245	1/10
135	4
73	8
41	12
22	16
7.5	20

Table 2—Military Standard Specifications for Contact Spacing at Various Voltages

Service Rating Under the MS Spec.	Test Voltage* (rms at 60 cps at sea level)	Effective Creepage Distance (nominal)	Mechanical Spacing (nominal)
INST.	1000	1/16	—
A	2000	1/8	1/16
D	2800	3/16	1/8
E	3500	1/4	3/16
B	4500	5/16	1/4
C	7000	1	5/16

*When the test voltages as noted are applied for a period of 1 minute between the two closest contacts and between the shell and the contacts closest to the shell, there shall be no evidence of breakdown.

Table 3—Temperature Limitations of Insulation Materials

Temperature Limit (F)	Material
250	Phenolic (paper-filled)
	Phenolic (cotton fabric-filled)
	Melamine 1502
	Polychloroprene, resilient
275	Bakelite BM-120
300	Nylon (Zytel) 101 or 105
350	Diall 50-51 (Dacron-filled)
	Silicon rubber (Silcan 63), resilient
400	Melamine (glass-filled) FF55
	Kel-F
	Teflon
	Phenolic Durez 14893
	Diall 50-01 Loal (asbestos-filled)
	Diall 52-20-30 (glass-filled)
450	Silicone (glass-filled) DC301
500	Silicone (mineral-filled) DC2106
	Phenolic (glass-filled) PCG400
1800	Steatite ceramic
2400	Alumina ceramic
2900	Zircon oxide

1. All insulating materials have 100 megohms minimum resistance up to temperature limit recommended here.
2. Materials listed are good for 500 hours continuous operation up to temperature limit recommended here.

built into the connector. The explosive charge assures extremely rapid and complete separation of the connector halves at the precise instant desired for stage separation.

Special-Purpose Types: The varieties of plugs and receptacles created for special purposes defy classification. Many have features which perform a mechanical or hydraulic function as well as an electrical one. One such type is used for connecting air-pressure lines and electrical circuits in a wind tunnel, Fig. 16. It is built either with all air connections or with a combination of air and electrical terminals.

Electromechanical Factors

After a basic type of connector has been tentatively selected, there are still many special electrical and mechanical design requirements which must be satisfied. The importance of each is discussed here.

Number of Contacts: So far as electrical and mechanical selection factors are concerned, number of circuits which will be carried by the plug must be determined first. The reason is obvious—the number of circuits dictates the number of necessary connector contacts. Standard plug designs can be built with a large number of contacts, but even miniature plugs can have many contacts if current is low enough. A comparison of miniature and standard connector insert sizes is made in Fig. 17.

Contact Size and Spacing: Size of contacts in a plug, and the related factor of contact spacing, are determined when the current and voltage of each circuit are known. In the case of contact size, the controlling factor is the current that each contact must carry, Table 1. A comparison of contact sizes is shown in Fig. 18. The spacing of contacts—"creepage" distance—depends on the voltage difference between adjacent contacts and the type of insulation material used. Table 2 gives data on contact spacing. Also, if the plug is to be used at high altitudes, the reduced atmospheric pressure and ionization of air may cause flashover or corona effect between contacts which would not occur at sea level. This effect can be prevented by sealing the contact area or by spacing the contacts farther apart.

Style of Contacts: Special attention should be given to selecting contacts best suited to the electrical and mechanical job a connector must perform. Shown in Fig. 19 are the most common contact styles. Besides those in Fig. 19, there are thermocouple contacts for attachment to the lead-in wires of thermocouple heat-measuring devices, contacts for extremely high voltages, and contacts for use with taper pins, taper tabs, and flat-tape cables.

Insulation Material: The selection of a suitable insulation material depends largely on environmental considerations such as ambient temperature, hu-

midity, and vibration. The reason is that nearly all of the insulating materials commonly used in electrical plugs have comparable electrical properties in a normal environment. An exception to this would be in rf applications, where the dielectric constant of the insulating material could have a significant effect on performance.

Temperature limitations for various insulation materials used in plugs and receptacles are shown in Table 3.

Mounting Space: Dimensional limitations in the mounting area play a big role in the selection of a particular type of connector. Normally the receptacle side is the mounted portion, although in rack-and-panel installations both the plug and receptacle will be mounted on a structure. The shape of the mounting space, and the type and size of the mounting flange, are the factors to be considered. Typical different configurations and sizes are shown in Fig. 20. If space and weight-saving are important, the design may require miniature or subminiature connectors which are available in both rack-and-panel and cable plug-in types. Subminiatures are available with many of the features of larger connectors, including snap-in crimp contacts and snap-in coaxial contacts.

Coupling Method: Mechanical, environmental, and human considerations will dictate the type of coupling selected, Fig. 21. Probably the most popular type is standard screw-thread coupling, Fig. 21*a*, which is used on all standard AN, MS-E, and MS-R connectors. The comparatively fine screw threads

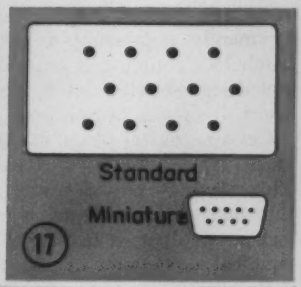


Fig. 17—Typical contact layouts for standard and miniature plugs.

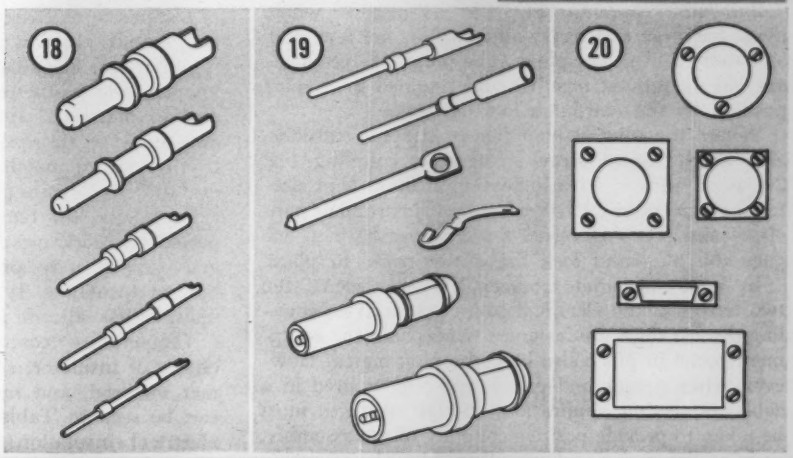


Fig. 18—Comparison of contact sizes.

Fig. 19 — Six different contact styles.

Fig. 20—Typical plug mounting configurations.

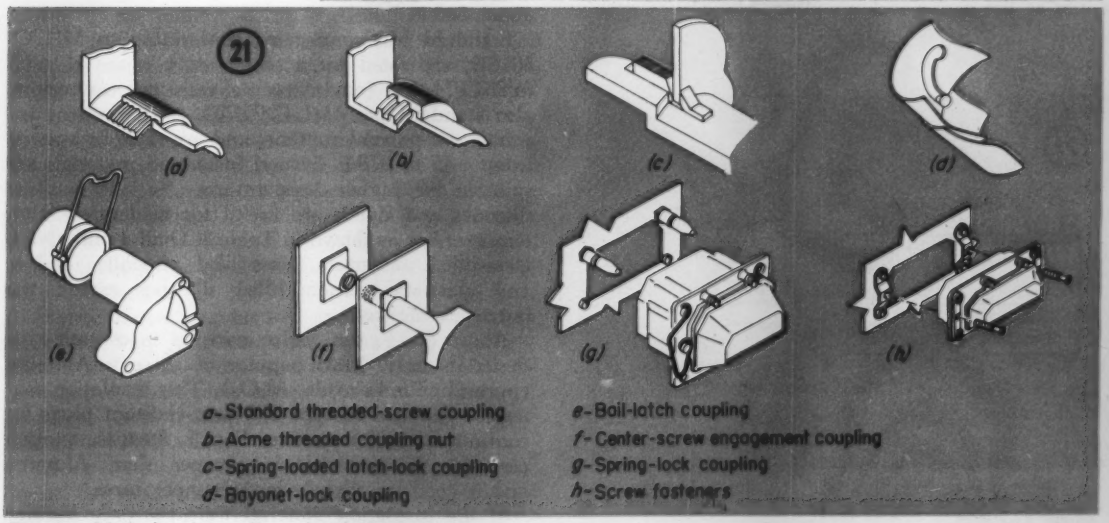


Fig. 21—Methods of coupling electrical connectors.

give an excellent mechanical advantage, and assure positive engagement even for high-density contact layouts where engagement and withdrawal forces are high.

Acme threaded coupling nut, Fig. 21*b*, uses coarse Acme screw threads, permitting the two connector halves to be mated with only a few turns of the coupling nut.

If there are only a few contacts in the connector, a spring-loaded latch-lock coupling, Fig. 21*c*, is quite suitable. This method of coupling is used on most audio plugs, and is preferred where ease and simplicity of disconnect are more important than mechanical strength of the coupling. The latchlock snaps into locked position after the connector halves have been pushed together, and can be disconnected by merely depressing a button with the thumb. Latch-lock coupling is generally effective for connectors designed with one to eight contacts, and with insert diameters of one inch or smaller.

Certain coaxial plugs, as well as some other miniature types, use bayonet-lock coupling, Fig. 21*d*. This method provides a quicker disconnect than threaded coupling nuts, while affording a secure, locked coupling. It does not, however, have the mechanical advantage of the threaded coupling nut.

Bail-latch coupling, Fig. 21*e*, is applied where plugs are large and heavy and contacts are few, such as battery and power plugs. The plug and receptacle are merely pressed together and retained in coupled position by the bail-latch locking device.

Where the plug assembly must support considerable weight, center-screw engagement coupling, Fig. 21*f*, is an answer. Its principal application is in electrical connections for hinged aircraft instrument panels, where the plug center-screw serves both to engage the plug and lock the entire panel in place.

In rack-and-panel mounting of equipment, the two halves of the electrical connector need no coupling device, since the fasteners which hold the equipment panel in place also keep the plug mated. However, when a rack-and-panel type plug is used in a cable-connecting application, special measures must be taken to provide positive coupling of the assembly, such as the spring-lock coupling, Fig. 21*g*. A spring wire fitting on the plug half snaps into localizing pins affixed to the receptacle. The spring locks and localizing pins can also be used for polarization.

Sometimes a screw-fastening technique, Fig. 21*h*, may be needed for positive retention of the mated plug and receptacle. Like the spring-lock coupling, it permits rack-and-panel plugs to be used in cable-connecting applications.

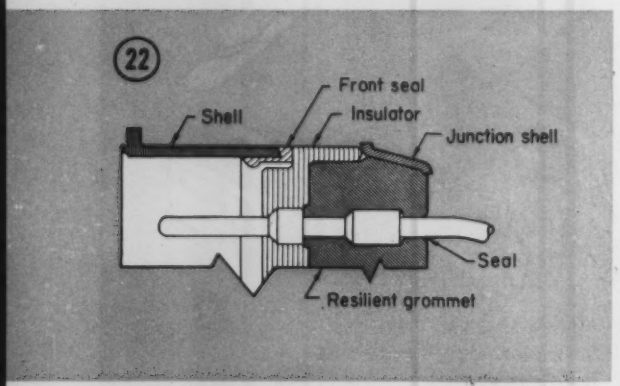


Fig. 22—Moisture sealing technique on plugs using a resilient grommet.

Environmental Factors

The environment in which the equipment will have to operate is important in selection of electrical connectors, too. Will the equipment be subjected to vibration or shock? If so, a rigid insulation material that would be perfectly satisfactory from an electrical point of view may be unsuitable. Will the equipment have to operate in high temperatures? If so, soldered wire terminations, satisfactory in lower temperatures, might melt. These are typical of the questions that must be asked about the environment. All environment factors should be studied from the point of view of normal level, time sustained, and maximum limits.

Temperature: Extremes in temperature and rapid temperature changes produce a generally deteriorating effect on electrical materials. Exposures to high temperatures cause permanent damage to most dielectric materials. Insulation resistance is lowered and moisture absorption is increased after exposure. In the case of metals, high temperature accelerates oxidation and causes plating to deteriorate.

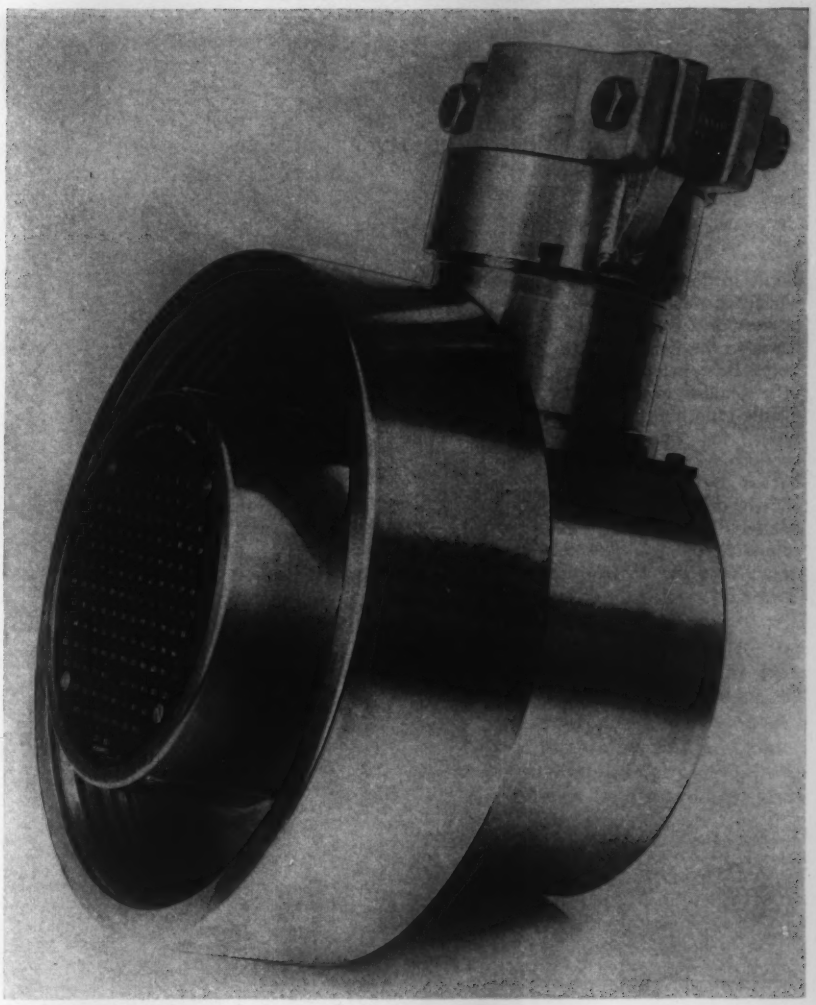
Extremely low temperatures, such as can be expected in Arctic exposure and in missile liquid-oxygen systems, may also cause cracks and delamination in insulators. It may cause failure of resilient seals, unless silicone rubber is used.

Temperature considerations will influence the choice of insulator, shell material and plating, contact material, and method of wire termination. As can be seen in Table 3, most of the more-common electrical insulation materials are only usable to about 500 F.

Standard MS connectors, conforming to MIL-C-5015D, are rated for a temperature range of −65 to 257 F. MS-R (environmental resisting) connectors, also standard per MIL-C-5015D, have resilient insulators of polychloroprene, and are rated to operate from −55 to 275 F. Several insulation materials are suitable for higher temperatures. Various resilient silicones and Zytels are useful for moderately high temperatures as shown in Table 3. Diallyl phthalates, glass-filled melamine, glass-filled phenolic, Teflon, and glass-and mineral-filled silicones extend the range still higher.

Above 500 F, the choice narrows to ceramic-type materials only. Most popular of these is Alumina (pure aluminum oxide, Al_2O_3). This insulation material is applied in type HR heat-resistant plugs for continuous 1000 F service, Fig. 5. Steatite, another ceramic-type material, is cheaper than Alumina and is good for slightly lower temperatures.

If the insulation material were the only limiting



Electrical plug for Polaris-launching submarines. The plug mates with a bulkhead receptacle which carries circuits from the submarine interior to the launching tubes. One such plug is fitted to each side of the bulkhead receptacle. Glass hermetic sealing is used in the receptacle to withstand 3000-psi pressures. Individual O-rings are used to seal each of the contacts in the plug. To resist salt-laden atmospheres and salt water, the plug is designed of stainless steel and nickel.

factor, plugs could be built with temperature ratings nearly to the melting point of Alumina ceramic, or about 2400 F. However, other factors, chiefly the melting point of good conducting materials for contacts, limit operating temperatures for plugs and receptacles to around 1000 F at present.

For temperatures above 300 F (either intermittent or continuous), care should be taken in the use of solder for attaching wires to contacts. Since common 60/40 solder softens at 361 F, and melts completely at 370 F, a high-temperature solder or crimp-type contacts should be specified if high temperatures will be encountered.

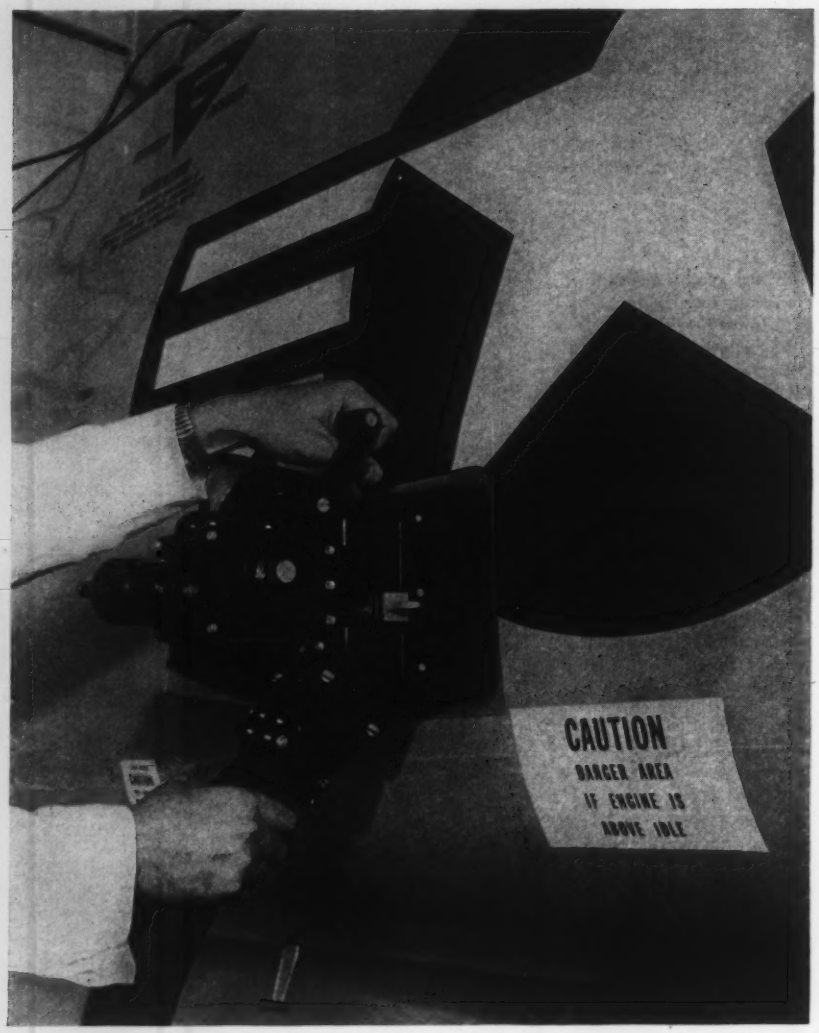
Plated contacts, generally applied in connectors for low and moderate-temperature applications, should not be used if temperatures above 500 F are anticipated. Solid silver alloys appear to be the most practical contact material at present for continuous use up to 1000 F.

As for the plug shell, stainless steel has been found to be the most satisfactory material for continuous use at temperatures above 500 F. For lower temperatures, anodized aluminum shells are generally satisfactory, and are especially good for aircraft or missile applications. Magnesium shells with anodic finish are suitable for temperatures up to 500 F.

Moisture and Humidity: When relative humidity is excessive, approaching values of 80 per cent or more, it becomes a major cause of electrical breakdown. If exposure to humidity, rain, spray, or water immersion is anticipated, sealed connectors are a must.

In moisture-sealed plugs, the wires pass through a resilient grommet at the rear of the plug, and a ferrule is tightened around the grommet, Fig. 22. MS-R plugs are moisture-sealed in this manner. For waterproofing of single-jacketed cables, a cable gland seal is recommended, Fig. 23. Here, the gland nut at the rear of the plug seals against the outside of the cable.

Sealing between the faces of connectors is also necessary if moisture-proofing and pressurizing are to be effective. Most sealed plugs achieve this "in-



Single large electrical plug which carries all ground power and warmup circuitry to the Convair F-106 Delta Dart prior to takeoff. Similar in design to missile-launching umbilical types, the plug can be connected and disconnected by a handle, as shown, or remotely disconnected by lanyard or solenoid.

terfacial" seal with an O-ring around one of the insulator mating faces.

Altitude and Atmospheric Pressure: The reduced atmospheric pressure and high degree of ionization encountered at extreme altitudes drastically reduce the insulation resistance of air. This condition becomes especially significant at altitudes of 30,000 to 35,000 feet and above. Electrical plugs are adversely affected by this change in the insulation properties of air, unless a sealing method is used to keep the air around the contacts at standard atmospheric pressure. Without such sealing, there is a greatly increased tendency toward voltage flashover and corona effect; nonsealed plugs used at high altitudes must be given a reduced voltage rating. For example, a nonsealed plug that could safely withstand 10,000 volts at sea level will "flashover" at about 1600 volts at 80,000 feet, assuming equal temperatures.

Resilient insulators, grommets, and O-rings are suited for pressure sealing high-altitude plugs. Pressure-sealing methods are similar to those used to seal against moisture and humidity. In fact, the same sealing method usually accomplishes both purposes.

Shock and Vibration: In equipment for high-speed jet aircraft and missiles, vibration and the related forces of shock and acceleration are major design problems. Acoustical vibration, transmitted to equipment by sound waves, becomes a problem when velocity passes the speed of sound or multiples thereof. In high-intensity acoustic fields, contacts chatter and contact resistance increases. Insulators, if not made of a resilient material, may deteriorate and disintegrate. For this reason, MS-R connectors or others with resilient insulators should be used if vibration is anticipated.

Shock forces, likely to occur in jet aircraft and

missile take-off, are similar to vibration in their deteriorating effect on components. Acceleration, a one-dimensional force which tends to distort the internal structure of components, is also pronounced in air and missile applications. Shock and acceleration, as well as vibration, should be taken into account when selecting insert material, contact style, wire termination, engaging method, and method of coupling.

Corrosive Environments: Salt spray and salt-laden atmosphere are often encountered along the sea coast, where many military electronic installations are located. Unless metallic surfaces are protected by a heavy plating or similar noncorrosive surface, rapid deterioration may occur under such conditions.

For this reason, a 50-hour salt spray test has traditionally been required for all military equipment. All AN, MS-E, MS-R, and similar Military Specification connectors are required to withstand this 50-hour salt spray test. Most nonspecification types have platings or anodic finishes capable of meeting

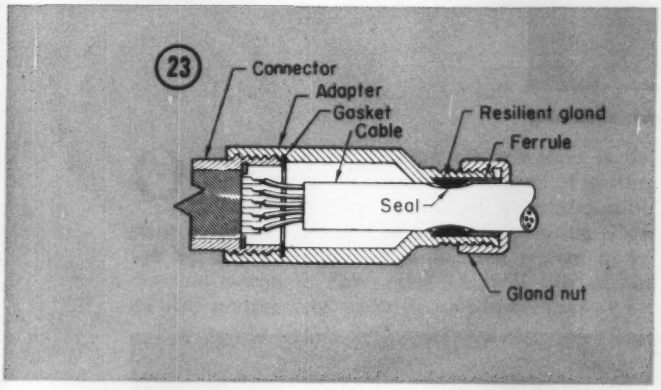


Fig. 23—Cable gland seal for waterproofing single-jacketed cables.

or exceeding this test. The 50-hour figure can only be taken as a rough estimate of service life under spray conditions, however. Prolonged exposure to salt-laden sea breezes may have corrosive effects similar to salt spray.

Other corrosive environments include fungus, acids, acid vapors, and hydrogen-sulfide vapor. These may require the use of special insulation materials, as well as special base materials and platings for contacts and shells.

Oil and Hydraulic Fluids: A special environmental problem occurs with electrical plugs applied in mechanical systems where motor oil or hydraulic fluids may come in contact with the plug. Synthetic rubbers and silicones, used for sealing grommets and insulators, are all adversely affected to some extent when soaked in these fluids. This is especially harmful in the case of sealing grommets. Certain oils and fluids can cause them to swell, rendering the seal ineffective. In general, neoprene or polychloroprene compounds are more oil-resistant than silicones or natural rubbers.

All connectors conforming to MIL-C-5015 (AN, MS-E, MS-R and MS-K firewall) must pass an immersion test in lubricating oil and petroleum-base hydraulic fluid. This test requires unmated MS connectors to be immersed for 20 hours in each fluid, after which they must withstand test voltages corresponding to their service rating.

With the wide variety of oils and fuels now in use in all types of aircraft, as well as the many types of synthetic rubbers now used in electrical connectors, it is difficult to generalize as to the adverse effects of oil exposure.

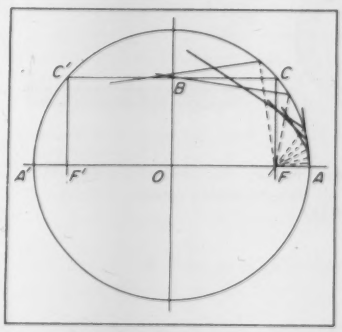
Radiation: Where the connector will be exposed to nuclear radiation, gamma rays, X-rays, etc., a connector with special radiation-resistant materials should be specified. Most common insulators, especially organic and resilient materials, will deteriorate rather rapidly under constant radiation exposure.

In general, materials resistant to extreme temperatures (in the 1000 F range) are also resistant to radiation. Thus, heat-resistant plugs, using insulators of Alumina or steatite ceramics, shells of stainless steel, and solid silver contacts, are the best radiation-resistant plugs now available. Such connectors may be used in nuclear reactor instrumentation where they are exposed to intense neutron and gamma ray bombardment for indefinite periods of time, and where the connectors must be disconnected and reconnected after long exposure.

Tips and Techniques

Constructing Ellipses

True ellipses can be simply constructed by the envelope of tangents. Given the major axis *A-O* and the minor axis *B-O*, a circle of radius *OA* is drawn. Find *F-F'* (the foci) by drawing the perpendiculars *BCF* and *BC'F'*. Any line through the foci has a



perpendicular which is tangent to the ellipse. An envelope of such lines can be rapidly drawn with a triangle.—Jesse Roth, *New York, N. Y.*

Pressurized and nonpressurized techniques for . . . . . .

HARRY C. RIPPEL
Senior Research Engineer
The Franklin Institute Laboratories
Philadelphia

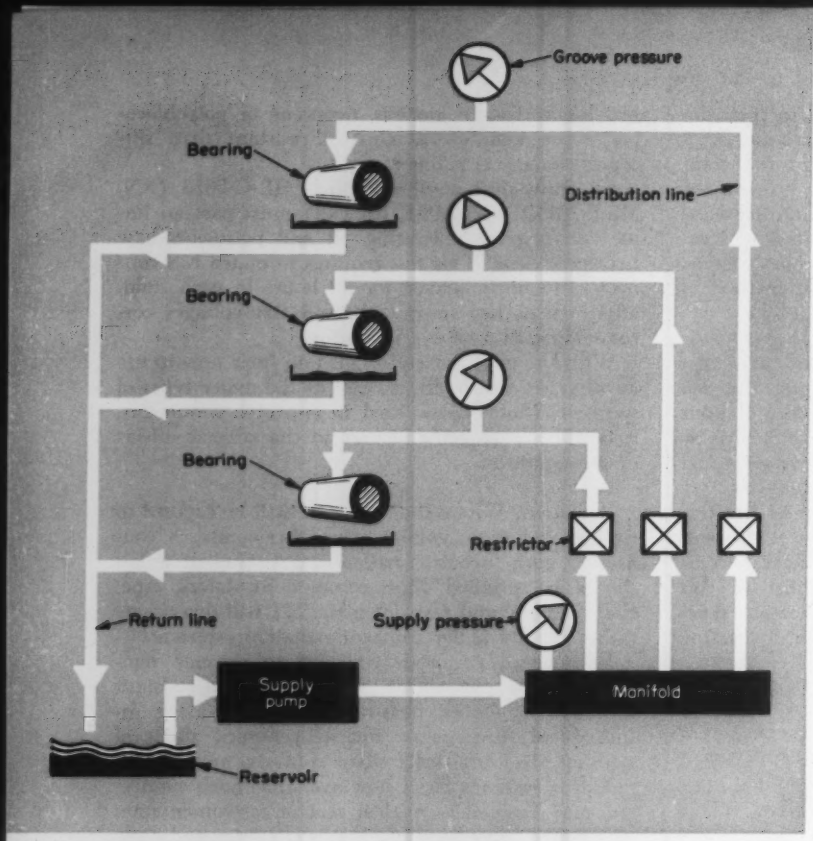


Fig. 50—Pressurized lubricant supply system containing three different bronze bearings.

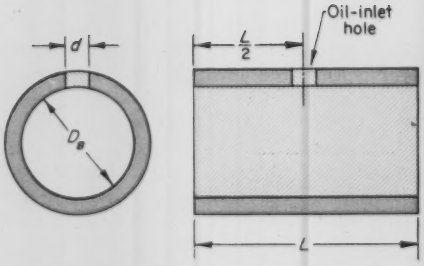
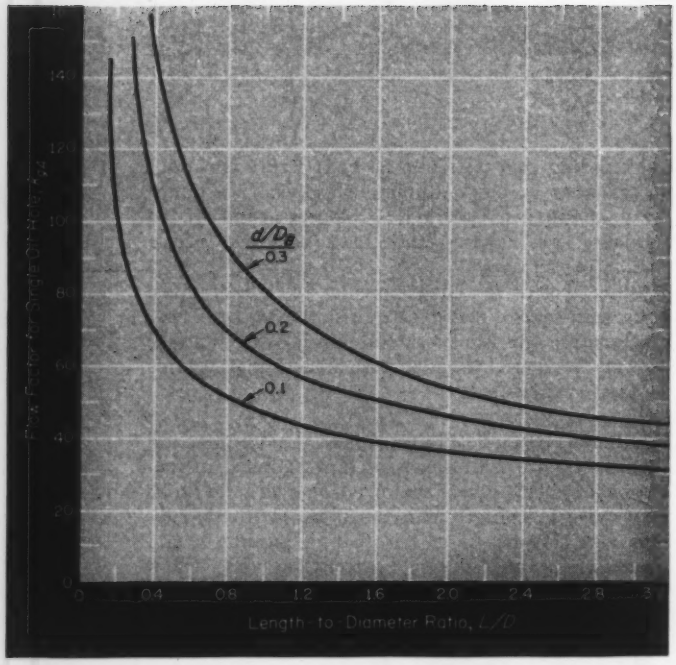


Fig. 51—Flow factors for centrally located single-hole oil groove with pressure lubrication ($D_B \approx D$).



Supplying Lubricant to Sleeve Bearings

- Calculating oil-flow rates
- Common lubricant-application methods

ONCE the actual bearing configuration is defined, there remains the problem of getting lubricant to the bearing in quantities sufficient to permit the desired type of operation. Does the application require a pressurized system to insure an adequate flow rate? Or will one of the simpler nonpressure methods be satisfactory?

This article will attempt to answer these questions by presenting, where possible, charts and equations for determining probable oil flow. With this information, the conditions required by the flow-rate equations for full-film and mixed-film (not boundary) lubrication can be satisfied.

In Part 1 of this integrated series of articles, based on a Design Manual sponsored by Cast Bronze Bearing Institute, theoretical flow rate for full-film lubrication is found from (see Reference 1)

$$Q = k_q m D^3 N \times 10^{-6} \qquad (9)$$

with side-leakage flow factor k_q obtained from Fig. 17. If the amount of oil supplied is less than Q, the journal will operate more eccentrically within the bearing than indicated in Fig. 13.

Also from Part 1, the equation for minimum flow rate for full-film lubrication is

$$Q' = 29.3 \times 10^{-9} \left(L + 0.0043 \frac{W}{D} \right) m D^2 N \qquad (10a)$$

Hence, to insure full-film conditions the bearing

Nomenclature

C = Radial clearance, in.
D = Journal diameter, in.
D_B = Bearing bore diameter, in.
d = Diameter of oil-inlet hole (Fig. 51), in.
h = Wicking distance from top of oil level to journal, in.
k_g = Groove flow factor
k_{gA} = Flow factor for pressure-lubricated single oil-inlet hole
k_{gB} = Flow factor for pressure-lubricated straight-axial distribution groove
k_{gC} = Flow factor for pressure-lubricated circular groove
k_q = Side-leakage flow factor
L = Bearing length, in.
L' = Length from centrally located circular groove to end of bearing (Fig. 53), in.
L'_1, L'_2 = Respective lengths from noncentrally located circular groove to each end of bearing (Fig. 53), in.
l = Length of straight-axial distribution groove (Fig. 52), in.
m = Clearance factor
= $1000\ (2C)/D$
N = Rotational speed of journal, rpm
p_g = Pressure developed in groove of pressure-fed bearing, psi
Q = Side-leakage oil flow, or oil-flow feed rate, gpm
Q' = Minimum oil flow required for full-film lubrication, gpm
Q_g = Oil flow in grooved, pressure-fed bearing, gpm
W = Steady load to be supported, lb
Z = Lubricant absolute viscosity, centipoises
ε = Journal eccentricity ratio

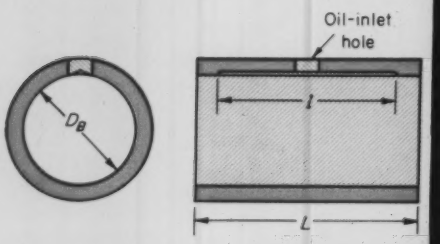
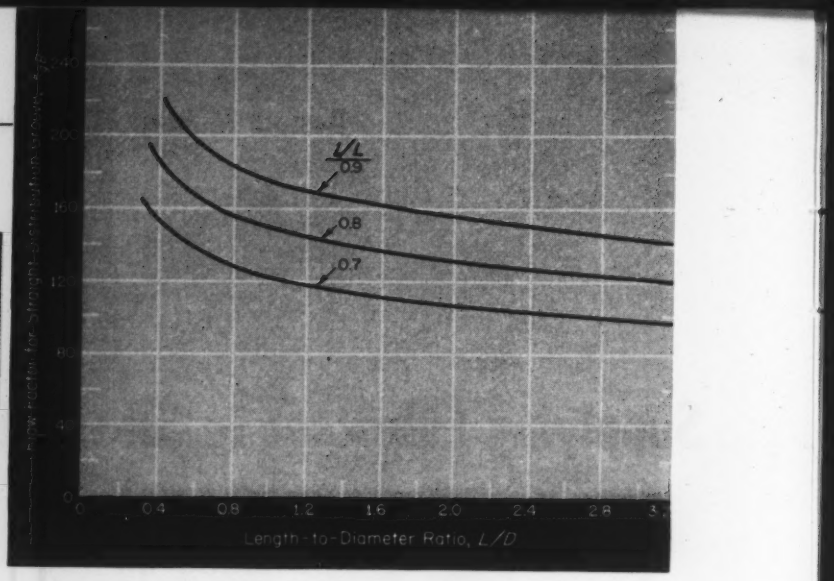


Fig. 52—Flow factors for straight-axial distribution groove with pressure lubrication ($D_B \approx D$).



must be supplied continuously with a flow rate at least equal to Q' and preferably equal to Q. If oil flow is less than Q', the bearing will operate under mixed-film conditions.

Pressure-Fed Bearings

With pressure feeding, lubricant is supplied to the bronze bearing under external pressure. Depending upon bearing requirements, pressurized lubricant may be supplied continuously for full-film lubrication or intermittently for mixed-film lubrication. The intermittent method is used extensively in centralized lubricating systems to supply prescribed amounts of lubricant to many different bearings at periodic intervals.

When pressurized lubricant is continually supplied, pressure is generated within the bearing groove because the narrow clearance between bearing members restricts oil flow. Actual flow through the bearing depends upon lubricant pressure in the groove, bearing diameter, clearance, bearing length, lubricant viscosity, and groove configuration. When the journal is concentric within the bearing bore, flow through the bearing is

$$Q_g = \frac{k_g m^3 p_g D^3}{Z} \times 10^{-6} \qquad (32)$$

Under load, the journal becomes eccentric with respect to the bearing and flow increases accordingly. Equation for the oil-flow rate of a loaded bearing is

$$Q_g = \frac{k_g m^3 p_g D^3}{Z} \left(1 + \frac{3\varepsilon^2}{2} \right) \times 10^{-6} \qquad (33)$$

Values for groove flow factor k_g in the following discussion are identified as k_{gA}, k_{gB}, etc., but can be substituted directly into Equation 33. Actually, D_B should be used in Equations 32 and 33 instead of D, but the numerical error is negligible. Use of shaft diameter agrees with previous flow equations and makes original L/D ratio valid for graphs which follow.

Oil-Groove Pressure: If only a single bearing is supplied with pressurized lubricant from a pump, groove pressure will be the same as the discharge pressure of the pump, assuming no line losses. If several bearings are supplied with pressurized lubricant from the same source, and again assuming no line losses, groove pressure developed within each bearing will be the same. Thus, if all bronze bearings in a system have identical configurations and operate under similar conditions, flow requirements for each bearing will be the same.

However, flow requirements are usually different for each bearing in a system and consequently require different groove pressures. In these situations, recommended practice is to install a restrictor in the distribution line to each bearing. Restrictors are merely devices inserted in the oil line to promote a pressure drop between manifold and bearing. Such devices include orifices, capillary tubes, needle valves, and flow-control valves. In addition to making the distribution line for each bearing independent of the others, restrictors also make full supply pressure immediately available to any bearing if required.

A schematic diagram of a lubricant supply system feeding three bronze bearings is shown in Fig. 50. Each bearing has a different groove pressure and requires an individual restrictor. Supply pressure is the same for all bearings. Proper "sizing" of restrictors to obtain desired flow rates requires some knowledge of pressure-flow relationships for the particular type of restrictor used.

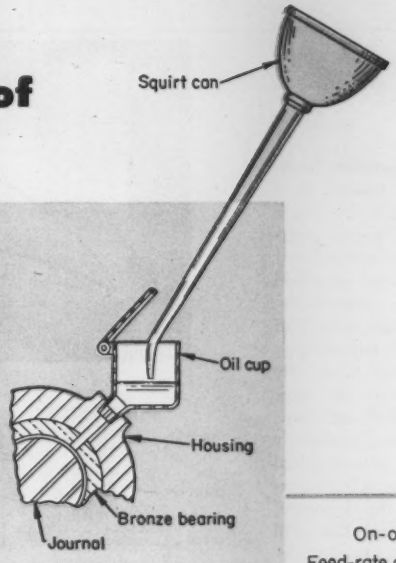
Thus, it is important to remember that p_g in Equation 33 is the groove pressure developed within the bearing. With p_g correctly determined, probable oil-flow rates can be predicted.

Single Oil-Inlet Hole: Flow factors for a single oil

Nonpressure Methods of Applying Lubricant

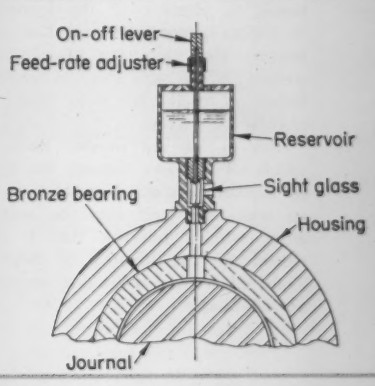
Hand Oiling

Many bronze bearings operating under boundary and mixed-film lubrication conditions are adequately lubricated by periodic hand oiling with a squirt can—provided oil application is not too infrequent. The bearing to be oiled is usually provided with a dustproof cover, and the lubricant, of course, should be clean. Actual oil-feed rate varies from copious shortly after oiling to nothing when the reservoir runs dry. Hence, if hand oiling is to be used, the bearing should be designed for complete boundary lubrication.



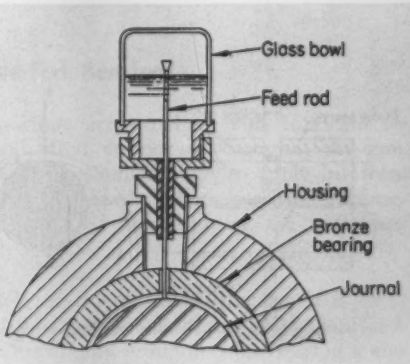
Drop-Feed Oilers

A big improvement over hand oiling is the use of drop-feed oilers. Flow rate can be adjusted and essentially held constant if oil level and temperature are not allowed to vary appreciably. Dropping rates ranging from 0 to 100 drops per minute are possible. Oil flow is normally started and stopped by hand, although such oilers can be made automatic by electrical or pressure devices.



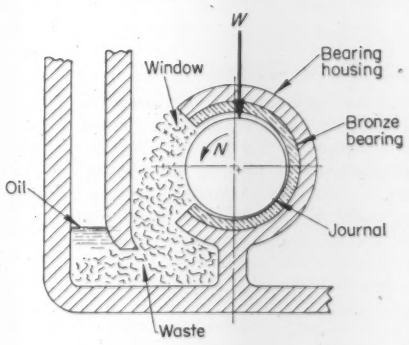
Bottle Oilers

A typical bottle oiler consists essentially of a clear "bottle" containing an extension tube. The bottle is inverted over the bearing and the extension tube rides the journal. Movement of the rotating journal causes the extension tube to move up and down, thus pumping oil from the bottle to the bearing. Delivery rate of oil depends upon the amount of motion available for pumping the lubricant. Oil flow is also very sensitive to temperature, which is an advantage because more lubricant will flow at higher temperatures when it is required. Another advantage is that oil is pumped only when the bearing is in operation. Because the lubricant supply is sealed, bottle oilers are widely used in dusty atmospheres.



Waste and Pad Oilers

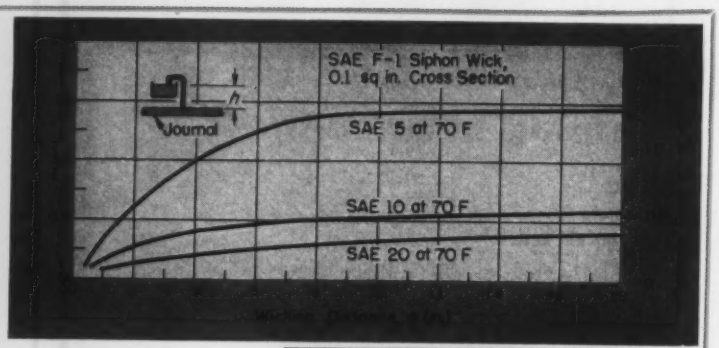
Capillary action accounts for the lubricating effectiveness of oilers using waste or pads which contact an oil reservoir at one end and the rotating shaft at the other end. Needless to say, oil-feed rates are difficult to predict. Maintaining oil in the reservoir is important and permits the waste to supply copious amounts of lubricant. Such oilers are used extensively for railroad freight-car journal bearings. The waste, in this case, provides effective lubrication under adverse conditions.

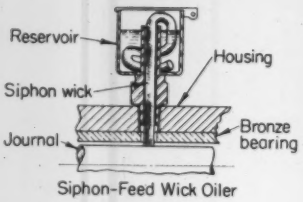


Wick Oilers

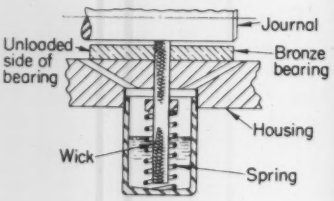
Use of a wick to transport lubricant from reservoir to bearing is a tried and true method. Lubricant moves through the wick due to capillary action. Although the method may appear to be quite crude, wick-feed oilers are efficient when properly designed. Flow rates possible with SAE F-1 felt for siphon and bottom type wicks may be estimated from the curves. Data presented are for wick areas of 0.10 sq in. for SAE lubricants at 70 F. Oil delivery rate is directly proportional to total cross-sectional area of the wick and inversely proportional to viscosity of the lubricant. At higher temperatures, oil flow will increase since lubricant viscosity decreases. Wicks also serve as effective filters to insure that only clean oil reaches the bearing.

Also in use are wooden wicks in which oil is drawn through the wood by capillary action. Normally, wooden wicks are built into the bearing along with a reservoir that is machined in the housing or bearing. Thus, all external wicks and reservoirs are eliminated.

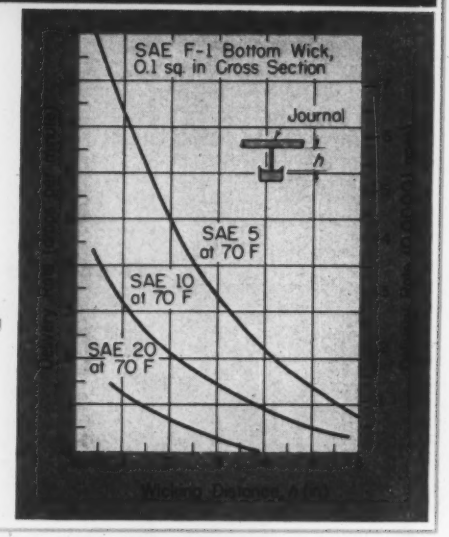


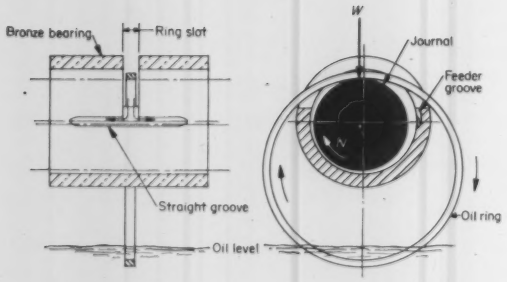


Siphon-Feed Wick Oiler



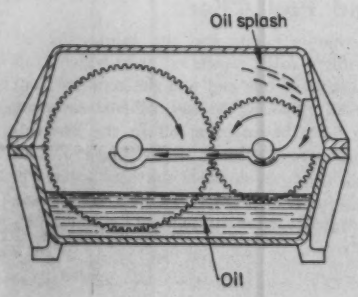
Bottom-Feed Wick Oiler





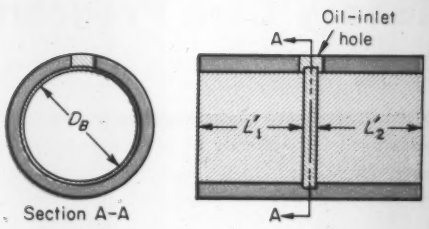
Ring and Chain Oilers

Copious amounts of lubricant can be supplied by the relatively simple means of hanging a ring or chain on the journal in a horizontal bronze bearing. At low speeds, the ring moves with the shaft. If the bottom of the ring is immersed in oil, it will, as it rotates, pick up and deliver oil to the bearing. If the oil is allowed to return to the reservoir to maintain the oil level, a constant supply of lubricant will be delivered to the bearing. Ring diameters are about 1½ to 2 times the diameter of the bearing. Minimum oil level should cover at least a 30-deg section of the ring. Chains can supply more lubricant than rings and require less space. However, they are not suitable for high speed because they tend to swing around the shaft. Oil supply rates of from ¼ to 1 gpm are easily obtained with rings or chains.



Splash and Bath Oiling

Often effective lubrication can be provided by splashing lubricant into suitable channels which then direct the lubricant to the bearings. Splashing may be accomplished by parts of the machine moving through a constantly maintained level of oil within the machine. In this case cleanliness of the inside of the machine is important to avoid contaminating the lubricant supplied to the bearing. Bronze sleeve bearings may also be operated in a bath of lubricant.



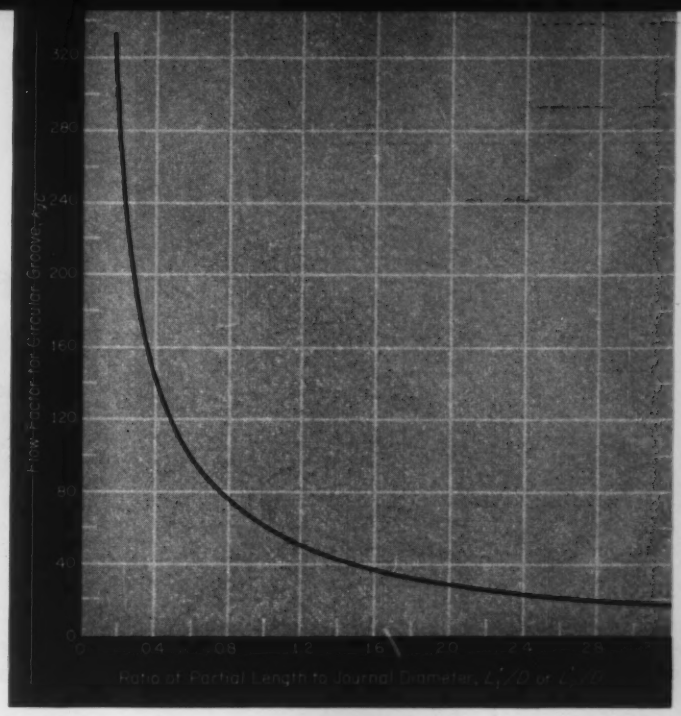


Fig. 53—Flow factors for circular groove with pressure lubrication ($D_B \approx D$).

hole, considered as a groove, can be obtained from Fig. 51 for various ratios of inlet-hole diameter to bore diameter. Oil flow can then be determined from Equation 33.

If calculated oil flow for the pressurized lubricant is more than that obtained from Equation 9 for full-film lubrication, the bearing should operate at the specified eccentricity ratio. If calculated flow is less than full-film requirements, the journal will be more eccentric within the bearing than anticipated. To increase the flow, either d/D_B ratio or pressure may be increased. Equation 33 and Fig. 51 may also be used to determine pressure required at the hole to yield the proper flow when hole size is fixed.

Straight-Axial Groove: Flow factors for straight-axial distribution grooves can be obtained from Fig. 52 for several ratios of groove length to bearing length. Ratios of l/L between 0.7 and 0.9 are recommended. To evaluate flow from a pressurized axial groove first requires determination of k_{gB} from Fig. 52 for particular l/L and L/D ratios. Since the other quantities are known, substituting k_{gB} in Equation 33 yields the flow rate.

If a pressurized feeder is used with a straight-axial distribution groove, oil flow will be somewhat more than for a plain, straight groove. However, use of flow factors from Fig. 52 for straight grooves is suggested when evaluating flow from a combination feeder and straight groove.

Circular Groove: Flow factors for a centrally located circular groove can be obtained from Fig. 53. In this curve the abscissa is L'/D with L' being the distance from edge of the groove to end of the bearing. After the value of k_{gC} is determined, substitution in Equation 33 permits evaluation of flow through one end of the bearing. Total flow will be twice this value if the groove is centered within the bearing.

When a circular groove is not axially centered within the bearing, two different values of L' exist: L'_1 and L'_2. Hence, the flow factor for each end of the bearing will be different. Therefore, Equation 33 must be used twice to evaluate the flow for each section. Total oil flow is then the sum of these two values.

Nonpressure-Fed Bearings

Bronze bearings are supplied with lubricant by many methods that do not use external pressure. Seven of the more common ways to apply lubricant are shown and discussed. Where possible, information on flow rates is furnished for the individual method.

Final article in this planned program will cover bearing wall thickness and retaining methods. Hardness, surface finish, and procedures for bearing maintenance and replacement will also be discussed.

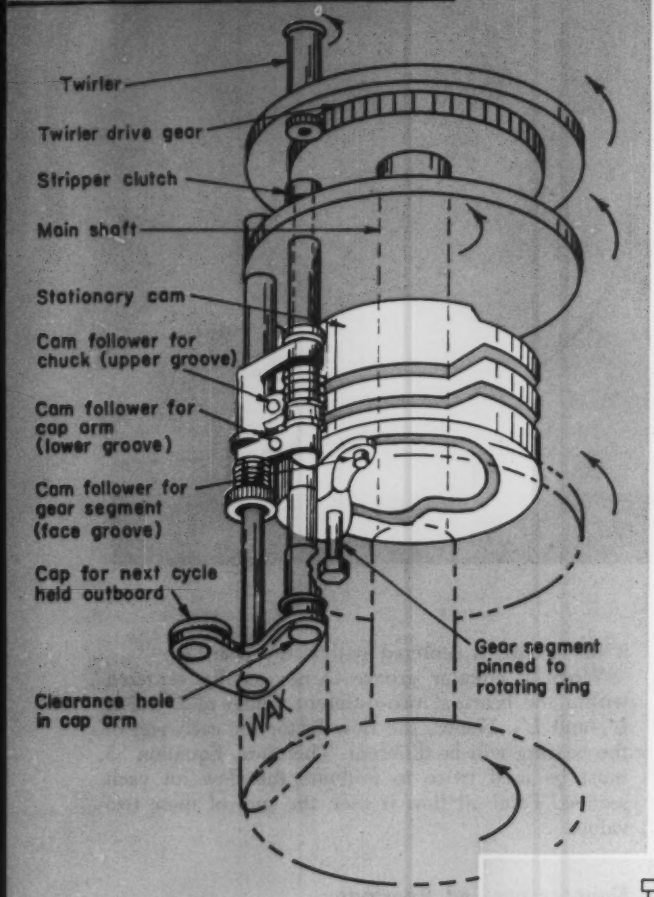
REFERENCES

This is the fifth in a planned program of six articles which will present the complete Design Manual sponsored by Cast Bronze Bearing Institute. Issues of MACHINE DESIGN in which previous articles appeared are:

1. "Bronze Sleeve Bearings" ..... September 17, 1959
2. "Viscosity and Lubricants" ..... October 1, 1959
3. "Sleeve-Bearing Bronzes" ..... October 29, 1959
4. "Grooving for Sleeve Bearings" ..... November 12, 1959

Minimum Bearing Length

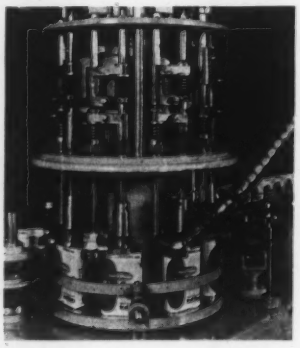
In "Bronze Sleeve Bearings," page 205, September 17 issue, Equation 24 for minimum length of bearing should be: $L_{min} = 0.00131NW/(T_2 - T_4)$.

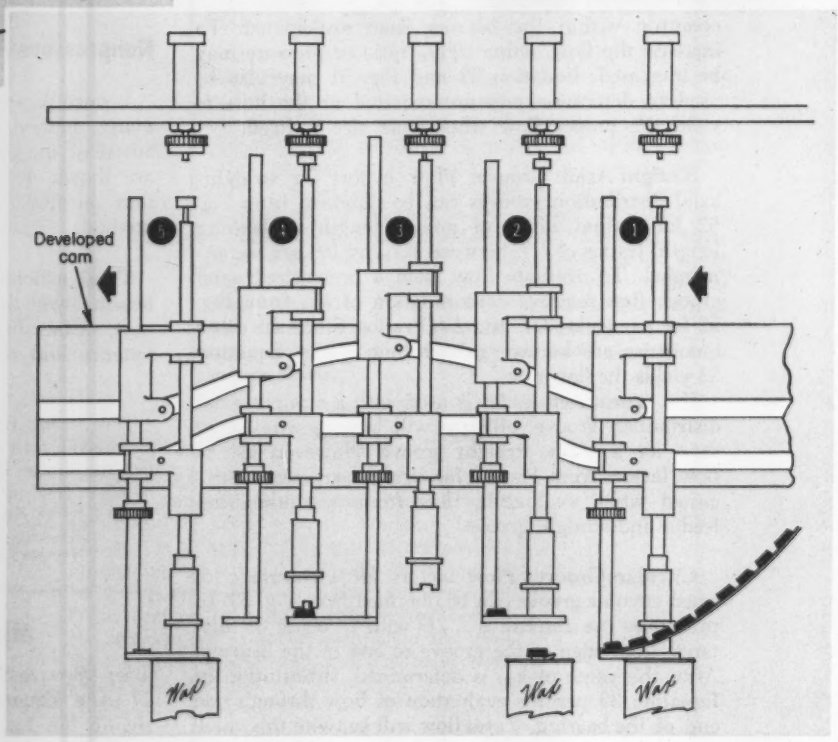

Twirler
Twirler drive gear
Stripper clutch
Main shaft
Stationary cam
Cam follower for chuck (upper groove)
Cam follower for cap arm (lower groove)
Cam follower for gear segment (face groove)
Cap for next cycle held outboard
Clearance hole in cap arm
Gear segment pinned to rotating ring
WAX

Stationary Cam Programs

ALL MOTIONS of chucks and cap-delivery arms are controlled directly or indirectly by a stationary cylindrical cam about which they rotate in a merry-go-round capping machine. Cylinder wall grooves control vertical motions of all shafts. Cap arms are rotated during cap delivery by gear sectors actuated by another groove in the lower face of the cam. Cam-guided vertical motion of chucks engages strippers and twirlers for cap orientation.

CAPS FOR THE NEXT ROUND are picked from feed chute by cap arm as it swings past. Inboard end of boomerang - shaped arm clamps the can and forms locating fixture for capping chuck. Slot in chuck orients retaining straps all in one direction.

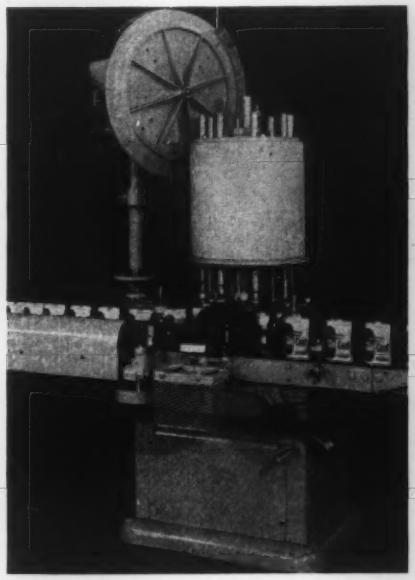




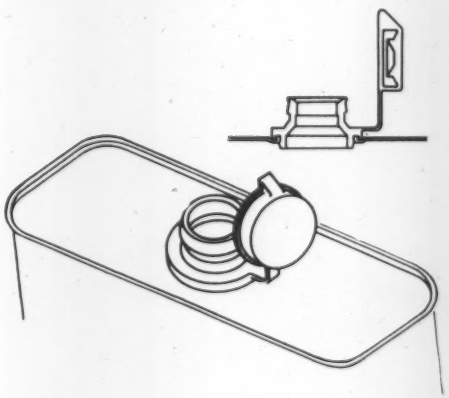
SEQUENCE OF OPERATIONS:

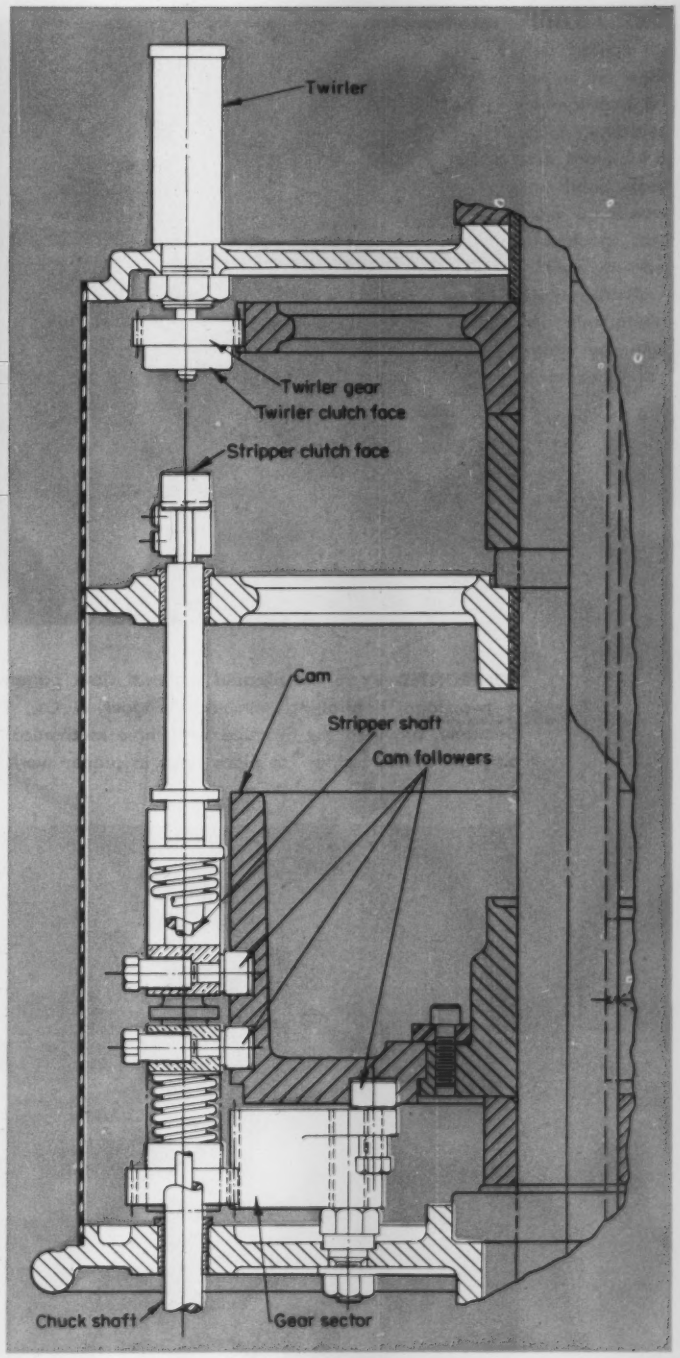
1. Passing cap arm picks cap from chute.
2. Both shafts rise to release finished can.
3. Twirler depresses stripper which clears chuck for next cap. Cap arm rotates forward to deliver outboard cap to preceding chuck.
4. Stripper clutched to twirler rotates cap until retaining strap falls in chuck's slot.
5. Arm and chuck move down to clamp incoming can, apply cap.

Merry-Go-Round Capper

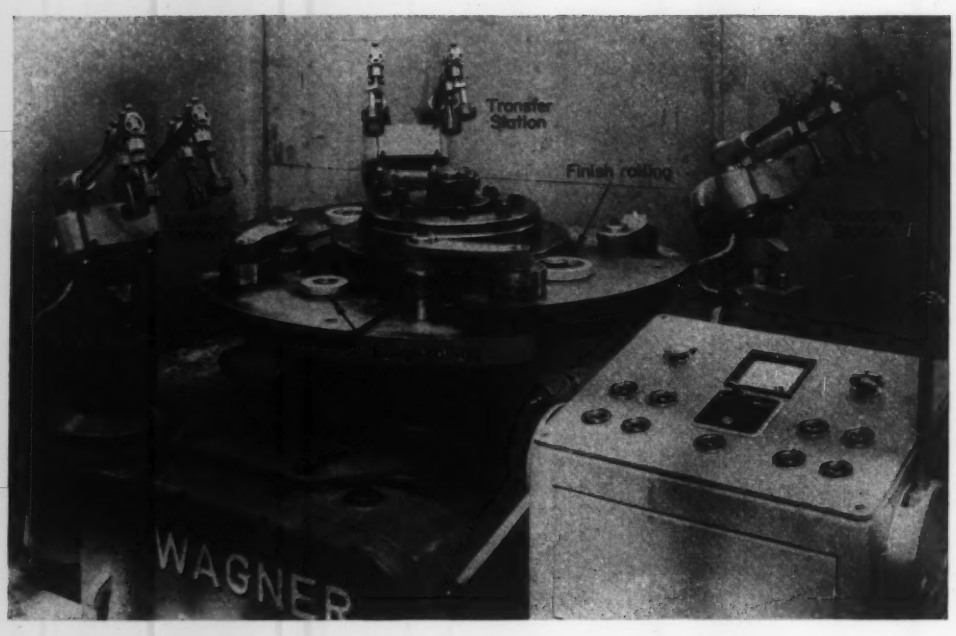


MERRY-GO-ROUND capping machine is a modification of Consolidated Packaging Machinery Corp.'s model D-8-F eight-spindle capper. Specifications called for a machine that would handle 200 quarts or 250 pints per minute. CPM has another version that puts Newman seals on gallon cans.

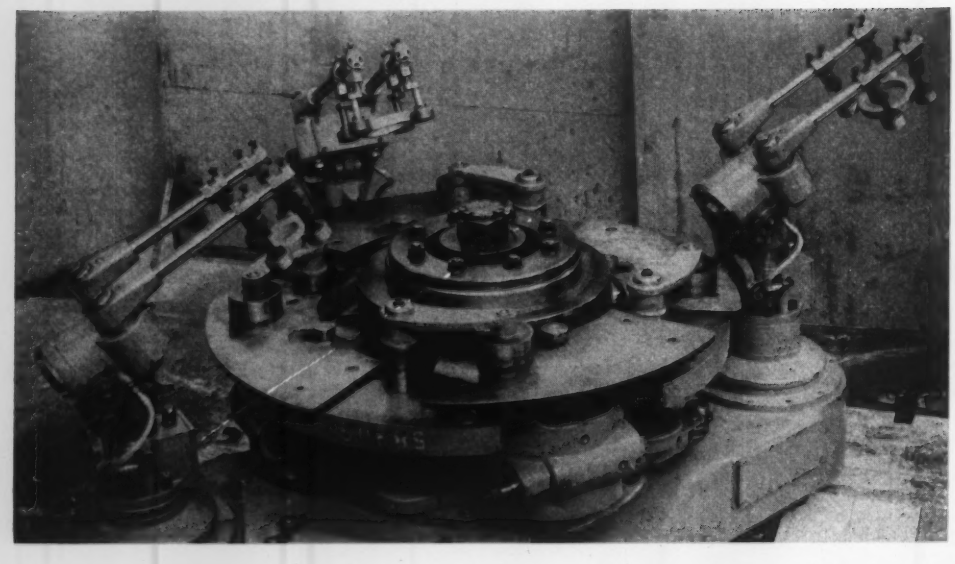




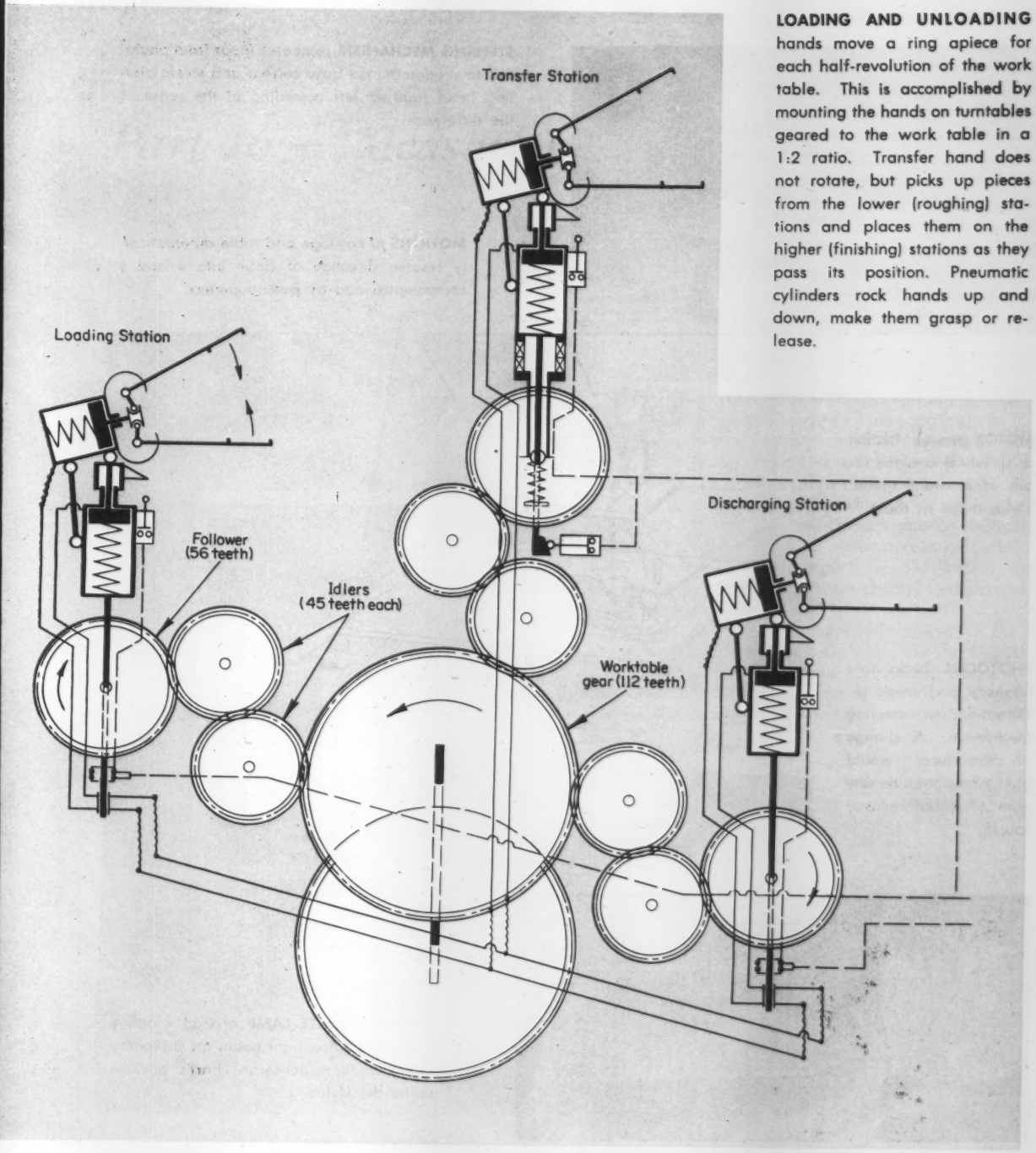
Gears Synchronize Hands and Worktable of



CONFRONTED BY a complicated material flow pattern through a two-stage ring-rolling machine, Wagner & Co., Dortmund, Germany, provided the machine with three mechanical hands to play a "checker game" to place rings in proper work positions.

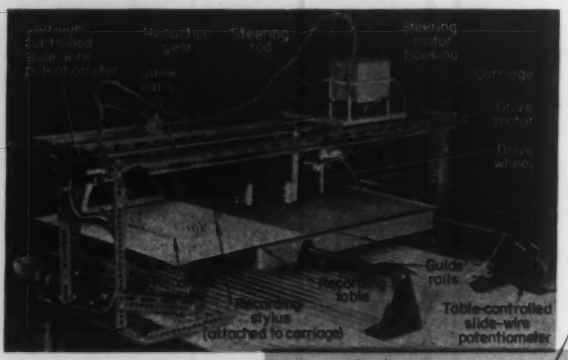


Three-Handed Ringroller



LOADING AND UNLOADING hands move a ring apiece for each half-revolution of the work table. This is accomplished by mounting the hands on turntables geared to the work table in a 1:2 ratio. Transfer hand does not rotate, but picks up pieces from the lower (roughing) stations and places them on the higher (finishing) stations as they pass its position. Pneumatic cylinders rock hands up and down, make them grasp or release.

Problem: Plotter for Equal-Intensity Curves
Answer: Self-Correcting Servo Loop



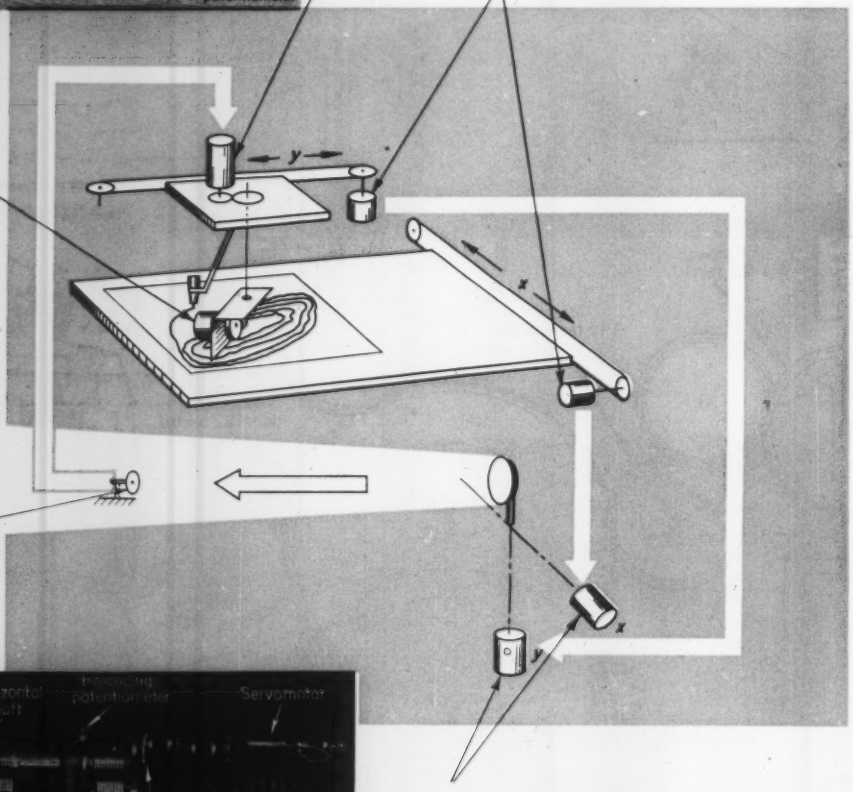
Plotter developed by Philips Research Laboratories, NY Philips Gloeilampenfabrieken, Eindhoven, Holland.

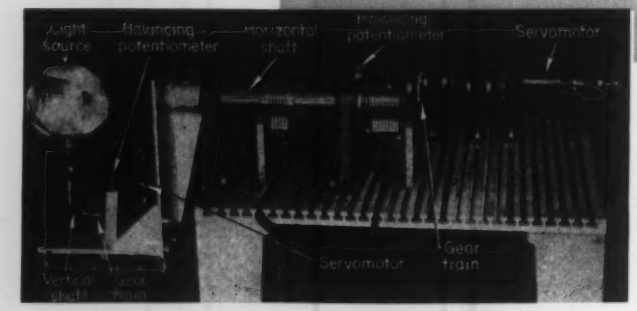
STEERING MECHANISM compares input from photocell to predetermined base current and steers plotting head right or left according to the sense of the difference.

MOTIONS of carriage and table automatically resolve direction of curve into x and y components read by potentiometers.

MOTOR moves friction drive wheel over the table at constant speed. Stylus maps its route.

PHOTOCELL checks light intensity and sends information to steering mechanism. A change of transducer would give information on any type of equal-intensity source.





MOTORS ROTATE LAMP around x and y axes to position light beam on stationary photocell in response to chart's position under the stylus.

Thermal Stresses in Design

Part 16 — Measurements by Photoelasticity

- **Model-Prototype Correlation**
- **Basic Features**
- **Techniques**

S. S. MANSON
Chief, Materials and Structures Research Div.
Lewis Research Center, NASA
Cleveland, Ohio

PHOTOELASTICITY is one of the oldest techniques of stress analysis. Its application to thermal-stress measurement is therefore natural. A logical extension would be to use conventional techniques, since the photoelastic model is sensitive to stress (or really strain), whether the stresses are induced by mechanical means or thermal constraints. Thus, it would seem necessary to impose only the desired temperature distribution in a photoelastic model and observe the induced stresses in the conventional manner.

However, thermal-stress applications involve certain complications not present when the loading is mechanical, such as: Imposing the desired temperature distribution, and accounting for the effect of nonuniform temperature on the mechanical and

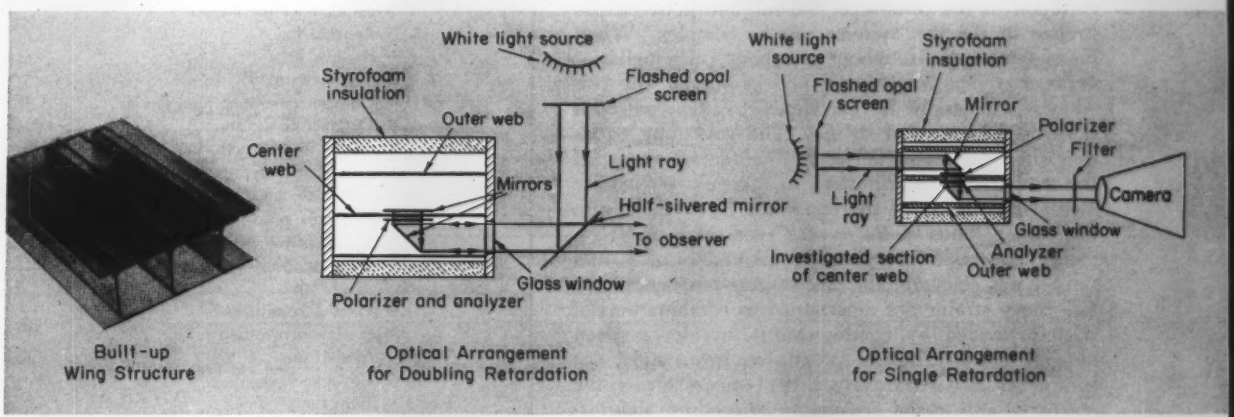


Fig. 93—Measurement of localized stresses in three-dimensional model of wing structure.

optical properties of the plastic specimen. Interpretation of test results on a model, in terms of the stresses that would be induced in the prototype, also required special consideration. When these factors are taken into account, the conventional approach, while useful, is limited to only certain types of applications.

Fortunately, the usefulness of photoelasticity is not limited to the application of the conventional techniques. The unusual properties of certain photoelastic materials, and the discovery of several analogies that can best be exploited through photoelasticity, have extended its usefulness many fold.

This article outlines the basic concepts behind photoelasticity as a tool in thermal-stress determination. While the specialized aspects of the subject will be discussed as needed, a knowledge of the rudiments of photoelasticity is assumed.[16,17]

Model-Prototype Correlation

Since the photoelastic specimen represents a model from which stresses or strains in the actual part are deduced, it is important to consider the relation between the two stress systems and the precautions that must be taken in planning and intepreting the tests.

Conventionally, photoelasticity has been applied primarily to problems in surface loading. In such cases, the stresses do not depend on the mechanical properties of the test part. For a given loading system, the stresses in the model are the same as those in the prototype. Solution to the plane-stress problem[6] is given by $\text{del}^4\phi = 0$, where ϕ is the stress function, and the stresses are determined as partial derivatives of ϕ. Hence, for specified surface stresses, the properties of the material never enter into the problem. On the other hand, the governing equation for a thermal stress problem is Equation 27, $\text{del}^4\phi + \text{del}^2 E\alpha T = 0$. If E and α vary with temperature in the model in an unrelated fashion to the variation in the prototype, the relation between the stresses in the two systems can be complex. When $E\alpha$ is constant throughout the body, although not necessarily equal for model and prototype, the two systems can easily be correlated by dividing both sides of the equation by $E\alpha$. The governing equation then becomes $(\text{del}^4\phi/E\alpha) + \text{del}^2 T = 0$. If the temperature distributions in the two systems are identical, solution of the equations for $\phi/E\alpha$ is also the same. Thus $\phi/E\alpha = f(T)$ or $\phi = E\alpha f(T)$. Since the stresses are given as derivatives of ϕ, and since $E\alpha$ is constant, the stresses are proportional to $E\alpha$. Since strains are determined as combinations of stresses divided by E, the strains are, for a given temperature distribution, proportional to α and independent of E. Alternatively, if the temperatures in the prototype and model are chosen to produce identical distribution of thermal expansions, αT (instead of reproducing temperature), the two strain systems are equal.

Photoelastic models, in general, have higher expansion coefficients than metal prototypes. Hence, the simulation of αT can be achieved in plastics with lower temperatures. However, two very important precautions must be observed: 1. The temperature range must be kept small enough so $E\alpha$ is reasonably constant. 2. The thermal-stress system must be separated completely from the effects of external loading, and each effect requires an independent investigation.

This second precaution does not imply that it is wrong to conduct a test on a photoelastic model involving both thermal and mechanical loading. If such a test is conducted, the observed stresses in the model will represent the actual stress distribution in the model. If the test is to check a computational procedure, and the model is simply a vehicle for verification, the procedure is valid. But, if the purpose is to predict the stresses in a prototype, it is difficult to separate those stress components which apply directly, without regard for material constants, from those which depend on the material constants. If each type of load is separately applied, the correlation to the prototype can be made, and the results combined.

When the effects of external loading are considered, a distinction must be drawn between loads whose magnitudes are specified and those which are induced by external constraints. A body which is, for example, rigidly fixed at three points, while subjected to an arbitrary temperature distribution, generally develops mechanical loading at the points of constraint. Such induced loading is analogous to internal constraints which develop thermal stresses. Stresses developed in the model are proportional to E. When the problem is broken down into its components, the constraints must be in-

[16]References are tabulated at end of article.

Nomenclature

E	= Modulus of elasticity, psi
I	= Moment of inertia, in.^{4}
L	= Length, in.
r	= Radius, in.
T, t	= Temperature, F
ΔT	= Change in temperature, deg F
u, v	= Displacements, in.
x, y, z	= Direction distances, in.
α	= Coefficient of expansion, in./in./deg F
ε	= Strain, in. per in.
μ	= Poisson's ratio
σ	= Stress, psi
ω	= Rotation, rad
Subscripts:	
h	= Heated condition
i	= Station or element
m	= Model
p	= Prototype
x, y, z	= Directions

cluded in the thermal stress fraction. Other external loadings of specified magnitudes should be separately investigated and the results combined.

Basic Methods

The photoelasticity technique is based on the retardation of polarized light passing through a stressed plastic model. When the proper optical system is used, retardation at any point is proportional to the difference between the principal stresses or principal strains. The distribution of retardation in the model shows up as a pattern of light and dark areas (or in the case of a white light source, a series of color patterns) which can be interpreted in terms of stress distribution.

The simplest information obtainable through photoelasticity is the maximum shear stresses (proportional to the difference between principal stresses) and the direction of the principal stresses. Although methods have been developed for separating the individual principal stresses, complications associated with these methods are not necessary for surface-stress determination. At any surface point not subjected to external loading, the normal stress is zero. Hence, the difference between the principal stresses becomes a measure of the tangential stress. Since surface stresses are usually of greatest interest, only the simplest of photoelastic techniques may be adequate.

Although techniques for three-dimensional photoelastic analysis have been developed in recent years, the simplest application involves the two-dimensional, plane-stress system. Many practical problems are, however, best represented as plane-strain problems. For example, heat transfer tubes, or the propellant grain of a solid-fuel rocket engine, are long bodies which have an axial temperature that is considered uniform. However, within any cross section of the tube the temperature may vary in an arbitrary manner. If the ends are considered constrained, the problem is one of plane strain. From an experimental standpoint, it is most convenient to analyze a slice of the body perpendicular to the axis, treating it as a problem in plane stress. After the stresses are determined for plane stress, the plane strain can be deduced by multiplying all stresses by $1/(1-\mu^2_m)$, where μ_m is Poisson's ratio for the plastic model.[18] Axial stresses, which are absent in the plane stress model, can be deduced for the plane strain model, since the axial strain is zero. Thus,

$$\varepsilon_z = \alpha_m T + \frac{\sigma_z - \mu_m(\sigma_x + \sigma_y)}{E_m} = 0 \qquad (119)$$

Hence,

$$\sigma_z = -E_m \alpha_m T + \mu_m(\sigma_x + \sigma_y) \qquad (120)$$

If the body is constrained at the ends, T is measured from the initial uniform temperature at which contact is established by the constraining surfaces without load. If no end constraint is imposed, T is measured from the average temperature in the cross section.

Once the stresses have been determined for the model, they may be determined for the prototype by multiplying by E_p/E_m. For plane strain, the axial stresses in the prototype are determined from Equation 120, replacing all subscripts m by p.

In other applications, it may be difficult experimentally to impose the temperature distribution without actually constructing a three-dimensional model. However, conventional two-dimensional techniques may still be applicable. Fig. 93 shows, for example, a method used to measure, photoelastically, the stresses in a built-up wing.[19,20] The important stresses are those in the web. Hence, the photoelastic field was limited by a mirror system to this location. In the one method, a photoelastic doubling system was used, whereby the light passes twice through the model, thus increasing the optical sensitivity when the web is thin. When the web thickness is greater, the conventional transmission-polarscope arrangement can be used.

Use of white light has also found much application in thermal-stress analysis. This is particularly applicable in the "photothermoelastic" approach, because of the greater sensitivity that can be achieved when the usable number of fringes is limited.

Photothermoelasticity: This term has been applied to the determination of thermal stresses actually

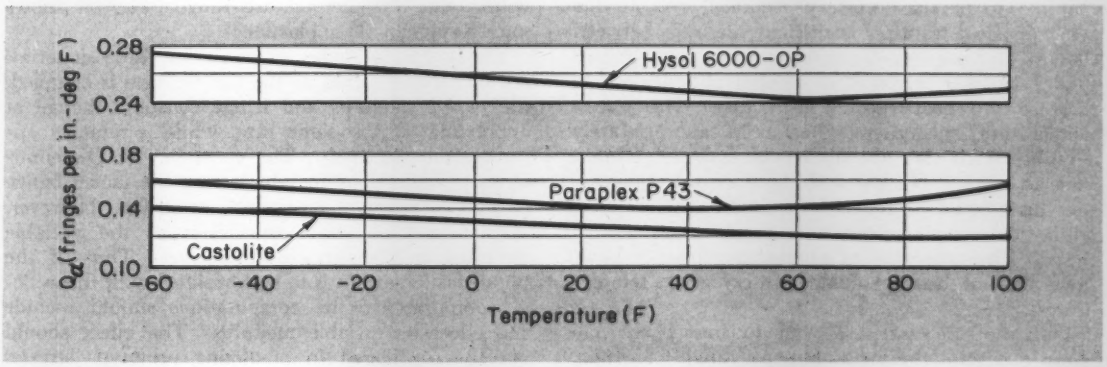


Fig. 94—Figures of merit for three photothermoelastic plastics.

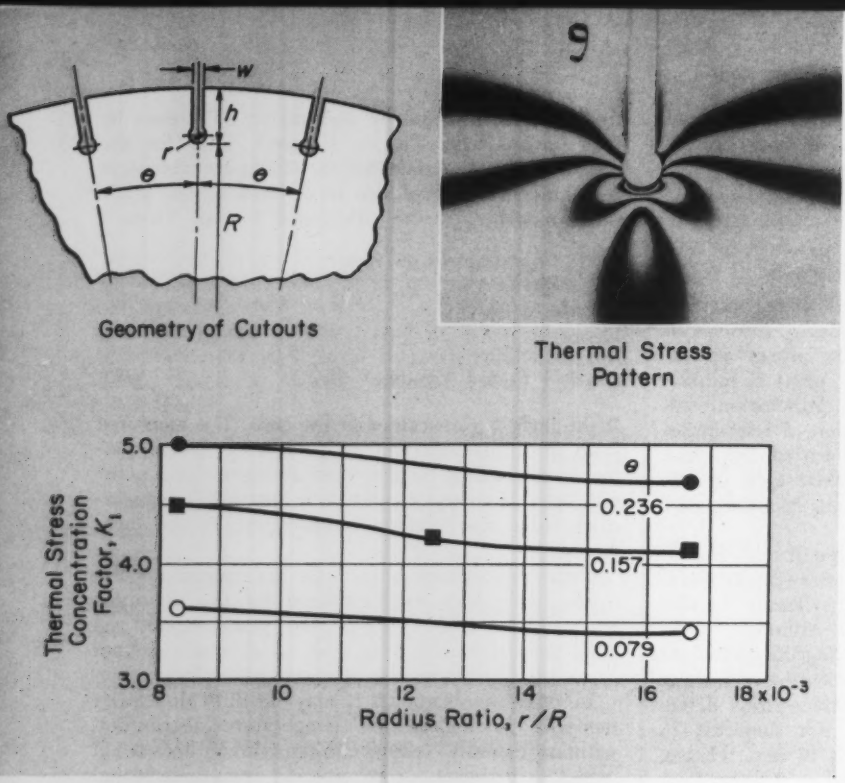


Fig. 95—Thermal-stress concentration factors for parallel-sided discs with rim cut-outs subjected to symmetrical radial temperature distribution.

induced in a photoelastic model by nonuniform temperature distribution.[21] Since most photoelastic materials suffer large changes in elastic modulus and photoelastic fringe value when the temperature is appreciably increased above room value, it is expedient to cool rather than heat the specimen. The thermal stresses developed during this procedure are of opposite sign, but for the fundamental elasticity studies to which the method has been applied, no distinction need be drawn between heating and cooling. Because the stresses measured are those actually thermally induced, the method is applicable to both transient and steady-state applications.

The type of coolant used to induce the temperature gradient depends on the number of fringes required to obtain necessary accuracy, and on the type of heat-transfer coefficient desired between coolant and model. Work to date has been limited to dry ice and mixtures of alcohol and dry ice to increase the heat-transfer coefficient. The lowest temperature encountered has been approximately −60 F. With the availability of cryogenic fluids, such as a liquid N_2, O_2, and H_2, the lower temperature limit could be reduced to almost absolute zero, while heat-transfer coefficients could be appreciably raised. The properties of photoelastic plastics have, however, not been evaluated at cryogenic temperatures.

It is not necessary to cool to induce thermal stresses within the measurement range. Heating, if moderate, can produce adequate stresses for measurement in some instances. However, temperatures must be kept low enough to maintain only a small variation in physical properties of the plastic model. For example, an epoxy resin has been used over a temperature range from 100 to 160 F.[22]

MATERIALS: Only a few materials have been evaluated for photothermoelastic application. The index of merit used is [21]

$$Q_\alpha = \frac{\alpha E}{f} \qquad (121)$$

For a given temperature distribution, the stress depends on the product αE, and the number of fringes developed for a given stress is inversely proportional to the fringe value, f. The quantity, $Q\alpha$, should be constant and as high as possible within the test temperature range. Fig. 94 shows some results for three plastics.[23]

The values of index of merit for these materials are uniform because, as the temperature is changed, the elastic modulus and fringe constant change at approximately the same rate, while α remains approximately constant. The constancy of $Q\alpha$ eliminates complications in interpreting the model fringe pattern in terms of its stress distribution. However, it does not eliminate the effect of the variable modulus on the stresses themselves. Thus, if the photoelastic pattern is to be correlated with theoretical computations, the computations should include the effect of variable modulus. The effect should also be considered in predicting prototype stresses from model measurements. Materials that permit

a wide test-temperature range without large variation in properties are desirable. In addition, the materials should fracture at a high stress, thereby permitting a large number of fringes to be developed, and should not creep or have time-edge effects associated with them.

APPLICATIONS: Photothermoelasticity has been used mostly to check theories and methods of computations, to obtain visual pictures of time-variation of stress in a complex shape due to thermal shock, and to determine the stresses around discontinuities which involve large stress gradients.

For example, the steady-state stress concentrations associated with thermal stress due to radial temperature gradients in circular plates in which cut-outs are present near the rim have been determined.[22] The plates represent turbine discs and the cut-outs are slots for bucket retention. Fig. 95 shows the geometry, a typical stress pattern in the vicinity of the cut-out, and the stress concentrations at point P. To obtain the actual stress at P, the nominal stress is multiplied by the stress concentration factor shown for the particular geometry involved.[24]

Some studies have involved transient thermal stresses in geometries simulating aircraft wing structures.[19,20] The most important problem in such built-up structures is the establishment of suitable assumptions for heat transfer between elements. Several theoretical techniques have been evaluated by comparing their computed values with experimental determinations.

Dislocation Analogy: By means of this analogy, the thermal stresses that would be produced in a multiply-connected body by the presence of a steady-state temperature distribution are mechanically induced by slotting the body to make it singly connected, and displacing the adjacent edges of the slots by controlled amounts.[25,26]

The analogy refers primarily to a long body, the greatest part of which can be considered in a condition of plane strain. If the body is conducting heat in planes normal to the axis, and a steady-state temperature has been reached, then from the classical heat conduction equation, $\text{del}^2T = 0$, the strains can be determined, subject to arbitrary boundary conditions consistent with the conditions of the particular problem considered. For a body in plane strain the biharmonic equation for thermal stress is Equation 27, $\text{del}^4\phi + [E\alpha/(1 + \mu)]\text{del}^2T = 0$. Hence, for the steady-state temperature distribution, the biharmonic equation becomes $\text{del}^4\phi = 0$.

If the body is singly connected, the complete solution becomes $\phi = 0$ with the boundary condition $\phi = \partial\phi/\partial\rho = \partial\phi/\partial y = 0$. This solution satisfies both the differential equation and the boundary conditions. Since the stresses are given as partial derivatives of ϕ, the stresses all become zero. Hence, the basis for the analogy is: A singly-connected body under steady-state temperature distribution produces no thermal stress.

Thermal expansions do develop within the body, but these expansions are compatible, since they can occur freely and the elements of the body still fit together perfectly without introducing any stress.

For a multiply-connected body having more than one surface, it is possible to choose arbitrary ϕ conditions at only one of the boundaries. The conditions at the other boundaries are determined by conditions of

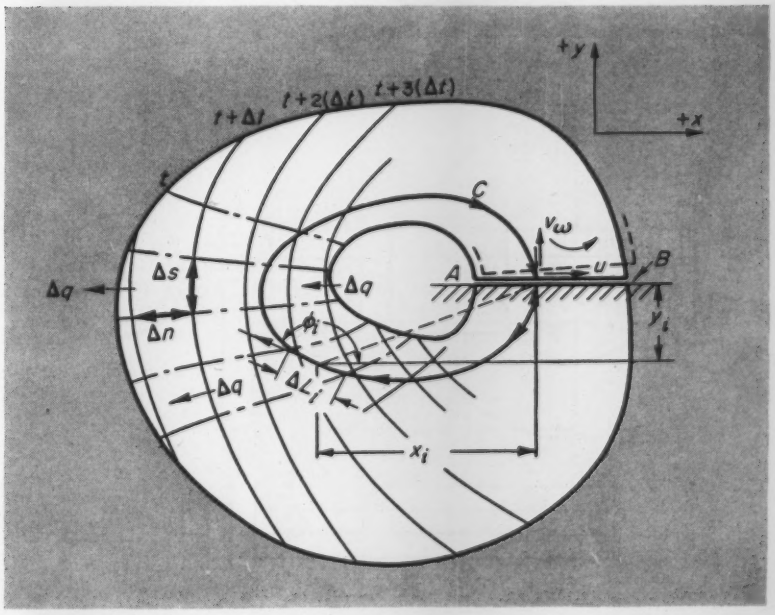


Fig. 96—Flow lines and isothermals on cross section of hollow cylinder.

displacements and rotations.[6,9] The easiest approach for determining the stress distribution is to convert the multiply-connected body into a singly-connected body by slits which join the boundaries. Adjacent faces of the slits, therefore, separate from each other by displacement and rotation. This brings the body to zero stress. The stress distribution that was present before the slit was made is determined by observing the stresses that are developed when the adjacent faces of the slit are brought back to coincidence by mechanically imposing dislocations equal in magnitude and opposite in sign to the thermal displacements of the stress-free body. Fortunately, the dislocations depend only on the temperature distribution. Hence, they can readily be computed if the temperature distribution is known.

Following the concepts of this analogy, simplified formulas have been developed for determining displacements and rotations of adjacent slits.[27] In addition, a deformeter has been devised. This apparatus displaces, by precalculated amounts, the adjacent faces of slits of a plane photoelastic model. The plane model has a shape of the body cross section normal to the axis.

This method is shown in Fig. 96 which represents the cross section of a hollow cylinder. The temperature distribution is presumed known, either from calculations, or from direct or indirect measurement. The first step in the method involves drawing isothermals of equal temperature spacing, Δt. A family of curves is then drawn normal to the isothermals. Passages bounded by these curves represent heat flow tubes. The spacing of the orthogonal family is such that the areas, bounded by the two sets of curves, are squares, $\Delta S = \Delta n$ for all cases. If the spacing is chosen to produce squares along one set of isothermals, squares are automatically produced for all other isothermals.

An imaginary cut is then placed along any convenient line AB. The lower edge of the cut is assumed fixed, while the upper edge takes displacements u and v, and rotation ω. These components are determined by drawing any curve C within the area of the cross section and enclosing the inner boundary. Preferably this curve should be an isothermal if the problem permits. If the distance along the curve between two flow lines is ΔLi, displacements at the cut are

$$\Delta u_i = (\Delta L_i)(1 + \mu)\alpha t_i \cos \phi_i + (\Delta \omega_i) y_i$$

$$\Delta v_i = (\Delta L_i)(1 + \mu)\alpha t_i \sin \phi_i + (\Delta \omega_i) x_i$$

$$\Delta \omega_i = (1 + \mu)\alpha(\Delta t) \qquad (122)$$

These expressions are summed for all flow tubes to give the displacements. Once these displacements are known, the slot in the stress-free model can be made large enough to accommodate a restoration of these displacements by mechanical means using a deformeter. The stress distribution produced by the mechanical deformations in the plane model are then observed photoelastically and represent the thermal stresses in the plane model. To convert to plane strain, these stresses are multiplied by the factor $1/(1 - \mu^2)$. To convert to prototype stresses these stresses are multiplied by $E_p\alpha_p/E_m\alpha_m$ if the actual temperature has been simulated, or by $kE_p\alpha_p/E_m\alpha_m$ if the temperature gradients in the model have been

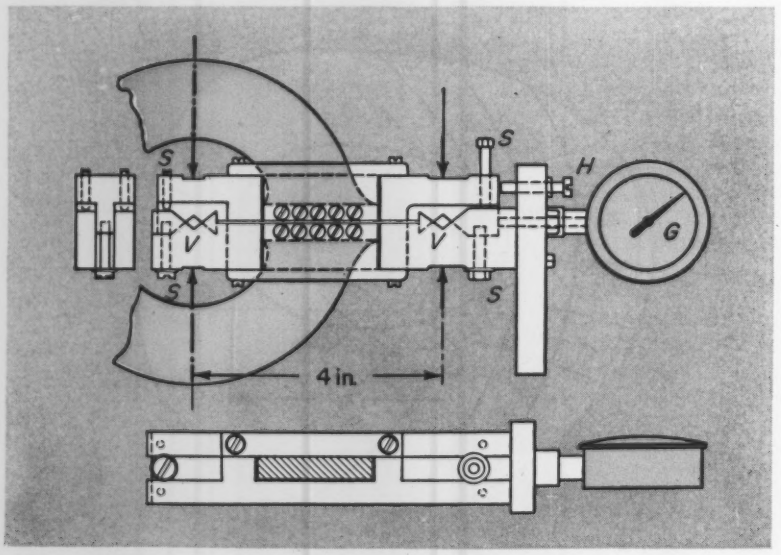


Fig. 97 — Weibel's deformeter for producing dislocations.

reduced by a factor of k relative to the prototype.

The deformeter, Fig. 97, is a rather rugged device since it must impose the large forces involved in producing the displacements. The dislocations ω and v are produced by inserting pins in the 90 deg V-grooves. The grooves are sloped to accommodate standard taper pins, thus permitting continuous variation of ω and v. Loading the model is facilitated by the vertical adjusting-screws S, which may also be used to fix ω and v, and thus permit the addition of a dislocation u. The latter dislocation is introduced by the horizontal adjusting-screw H, and its magnitude is recorded by the removable dial gage G. The magnitudes of ω and v are measured with micrometer calipers across the deformeter at the sections where the taper pins are inserted. When Equation 122 is used to determine the displacements, flow tubes within the rigid clamped area of the deformeter should not be included in the computation. Accuracy can be improved by choosing several independent curves about the internal boundary for determining displacements, and by choosing cuts in several independent locations. The cuts should be selected along a heat-flow line if possible.

Hence, this analogy permits thermal-stress measurements to be made without establishing a nonuniform temperature distribution in the test specimen. On the other hand, it cannot account for any effects due to property variations resulting from temperature effects. Furthermore, it is suitable for measurement of thermal stress only in the steady state.

This analogy has been applied to propellant grains of solid fuel rocket engines.[28] The geometry of an eight slotted grain is shown in Fig. 98 and the cut is taken as plane AA. The temperatures in the problem are constant but unequal at the inner and outer surfaces. To determine the steady-state temperature distribution, an electrical conducting paper, cut to the shape of the rocket grain cross section, was subjected to fixed voltages along the inner and outer edges.[29] By analogy between heat and current flow, the voltage distribution in the conducting paper is a measure of the temperature distribution when the edges are at constant temperatures. Any boundary conditions of temperature can be simulated by suitable edge voltages. Thus, temperature distribution can readily be determined by simple voltage measurements. Stress concentration factors were photoelastically determined by the dislocation analogy to be used in determining the maximum tangential stress in the star of the grain.

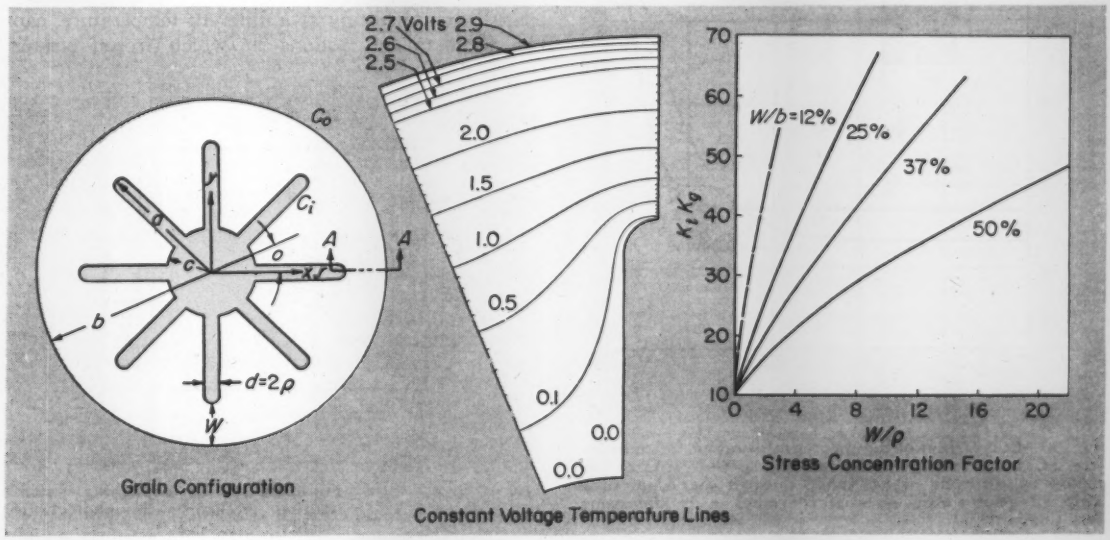
Diffusion Analogy: This analogy is based on the identity between the equations governing diffusion of heat and water vapor under certain conditions in organic solids.[30] Both processes are described by the differential equation,

$$\frac{\partial u}{\partial t} = D\left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} + \frac{\partial^2 u}{\partial z^2}\right) \qquad (123)$$

where D is a diffusivity for the process considered.

When heat diffuses into the body, the temperature changes cause approximately linear swelling due to thermal expansion. When water vapor diffuses, a similar, approximately linear swelling is caused by water absorption. In both cases, any inability of the individual elements to expand freely in accordance with its free dimension in the swelled state introduces a system of internally balanced stresses. Since many of the conventional photoelastic materials are sensitive to water-vapor diffusion, observation of the vapor-induced stresses may lead, by

Fig. 98—Temperature and thermal-stress concentration factor for eight-slotted grain rocket propellant.



analogy, to the thermal-stress distribution. Both the stress magnitude and the time scale are different in the analogs, but the magnitude of the diffusion constants, when compared with thermal diffusivity, is such that the analog gives the stresses at very early times.

Fig. 99 shows the photoelastically determined stress distribution in a long strip of plastic, suddenly exposed at its edges to an atmosphere of water vapor. Corresponding stresses computed for the strip subjected to a step change in edge temperature are also shown.

Some question exists as to the generality of this method to the three-dimensional "freezing and slicing" technique. Since stresses induced by the water vapor diffusion are true macroscopic stresses, just as are thermal stresses, any cuts in the body change the boundary conditions, and therefore the stresses change in most cases. In special cases, however, it is possible for slicing not to have an effect on the stress distribution.[30]

Expansion Release Method: One of the interesting properties of some photoelastic materials, usable in thermal stress analysis, is the ability to retain stored strain without application of external load. Release of this strain at the proper time simulates a thermal expansion, and its effects on the body in which it is incorporated can be visually observed because the material has birefringent properties as well.

The ability to retain stored strain is not a new property of photoelastic analysis. It is the basis of stress-freezing, one of the most useful three-dimensional photoelastic techniques developed to date. However, the particular way in which it is applied to thermal-stress studies is novel.[31]

The basis for the stored strain property of certain plastic materials is illustrated by the model in Fig. 100. Such plastic can be regarded as two-phase systems—a mechanical spring and a parallel arrangement of two oil dashpots.[18] At low temperatures the viscosity of the oil is so high that an externally applied load is absorbed mostly by the dashpots. Hence, the dashpots creep very slowly, transferring some of the load to the spring. If, however, the temperature is raised, the oil loses its viscosity, the dashpot creeps rapidly, and the load is transferred to the spring more rapidly. Within a reasonable time, all the load is carried by the spring. The deflection of the spring, which is assumed to be perfectly elastic, is much larger than when the oil is cold. If the temperature is reduced while the spring is at its maximum extension, the oil congeals and retains the spring in its deflected position. The strain in the spring is locked for practical purposes at the low temperature, but can be released at any time if the temperature is temporarily raised and then returned to the low temperature.

Many photoelastic plastics consist of a two-phase system essentially similar to the spring-dashpot combination. When loaded at elevated temperature, the modulus is low and is governed by the elastic phase (spring). Arbitrary strains can be induced in sections of the plastic by suitable loads when the material is hot. Cooling the plastic under load freezes the strains. A body consisting of several different parts, each operating at a different temperature, can be built up of sections in which frozen strains

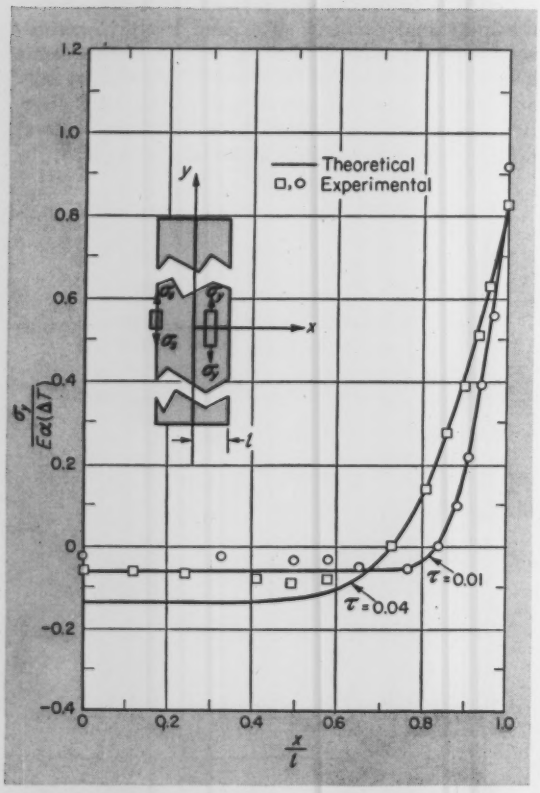


Fig. 99—Comparison of the theoretical solution for transient stresses, in a strip with heated edges, with stresses obtained by diffusing water vapor through the edges of a strip of photoelastic material. Symbol τ is dimension less time.

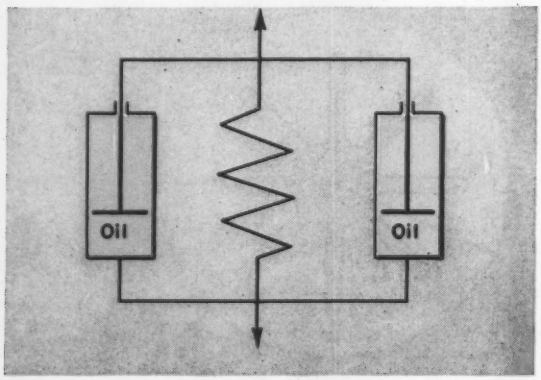


Fig. 100—Model explaining strain-freezing mechanism in photoelastic plastics.

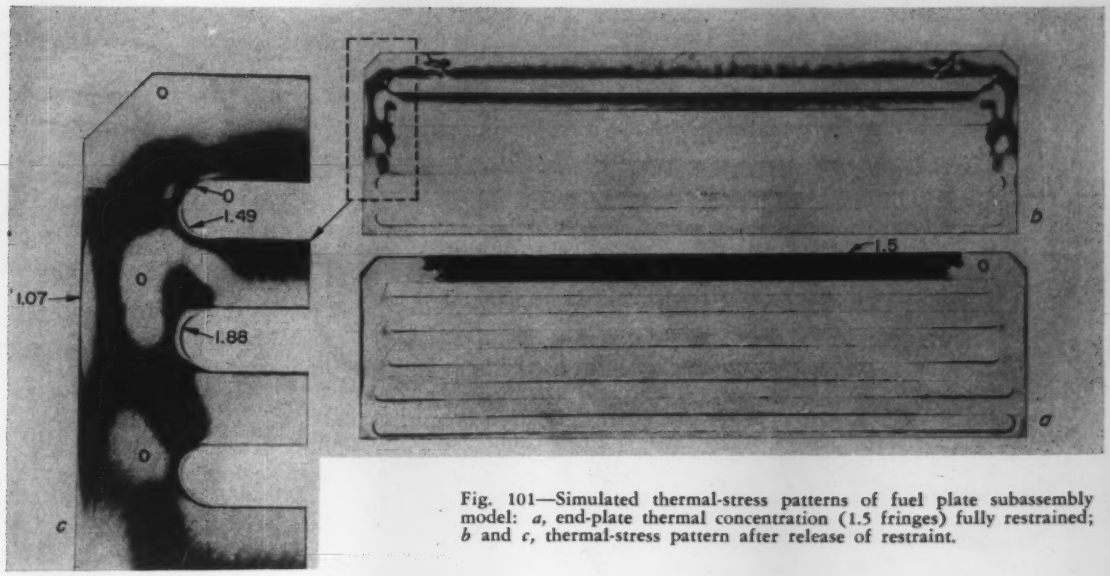


Fig. 101—Simulated thermal-stress patterns of fuel plate subassembly model: *a*, end-plate thermal concentration (1.5 fringes) fully restrained; *b* and *c*, thermal-stress pattern after release of restraint.

have been induced by prior mechanical loading. The amount of strain is proportional to the temperature. Many plastics that are suitable for strain freezing are also suitable for self-attachment. Therefore, these plastics are suitable for building up complex structures. After the structure has been built-up at room temperature, its temperature is uniformly raised to the critical temperature where the frozen strains would be released if no loads were present. The free length of each element increases as if it were subjected to a thermal expansion corresponding to the temperature in the prototype it represents. The thermal strains are, of course, not completely released, since, in the built-up structure, the internal constraints produce a stress system, just as differential expansion causes a thermal stress system. This stress system is frozen into the model when it is returned to room temperature. The magnitude of the simulated thermal stress is then determined by conventional photoelastic techniques.

The model, Fig. 101, represents a cross section of a fuel plate subassembly of a nuclear reactor. Because the end plates do not bear fuel, their operating temperature is lower than the other plates. Thus, a tensile pull by these end plates results on the remainder of the structure during operation. A complex stress distribution is produced where the side plate joins the fuel plates. In this case, simulation of thermal stress is very simple. A tensile thermal strain is frozen in only the end plate, and built into the structure, Fig. 101*a*. When the structure is heated to the critical temperature, the end plates contract and induce the stress system in the side plates, Fig. 101*b* and *c*.

The application is ideal for the stored-strain technique, because it involves large sections under uniform temperature, and uniaxial stresses obviously exist in regions where thermal strains were to be stored. Application of this method to more involved cases must be treated with caution.

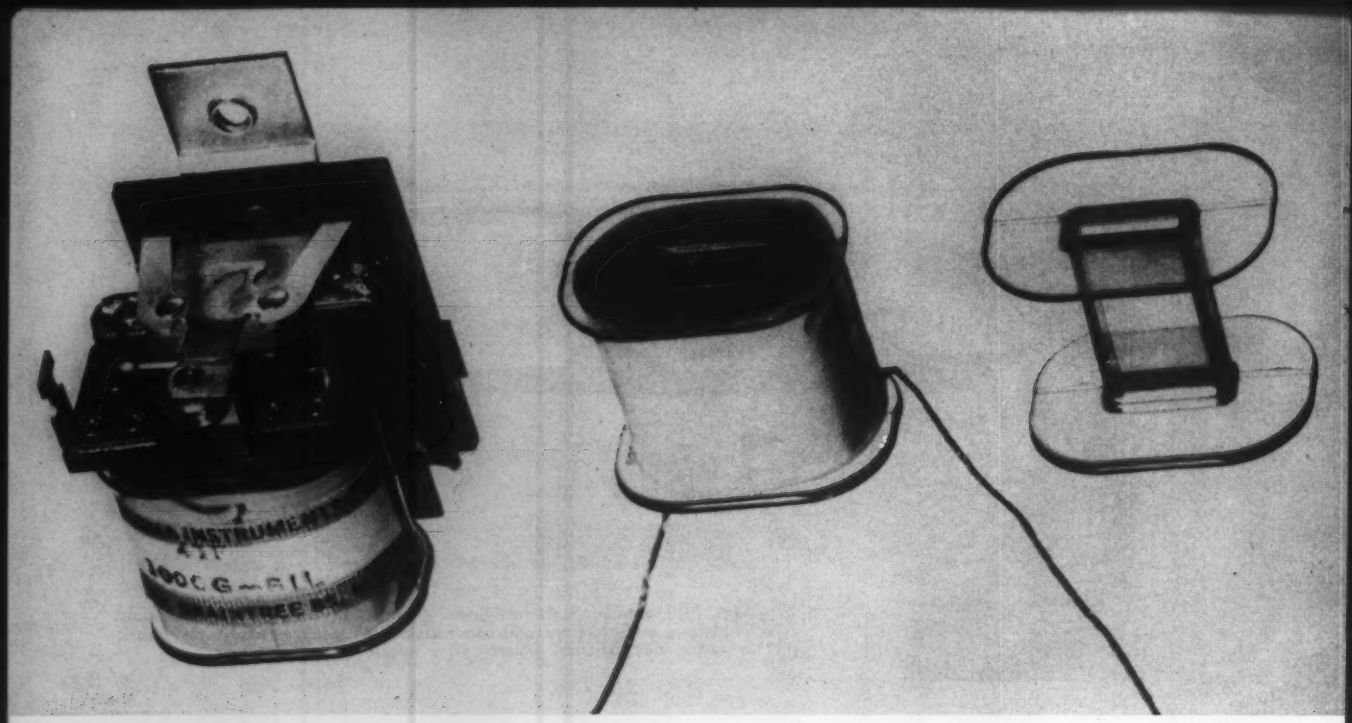
References

This article is the sixteenth in a series by S. S. Manson on thermal stresses in design. Previous articles and issues of Machine Design in which they appeared are:

1. "Appraisal of Brittle Materials" ..... June 12, 1958
2. "Quantitative Techniques for Brittle Materials" .. June 26, 1958
3. "Basic Concepts of Fatigue in Ductile Materials" August 7, 1958
4. "Causes of Fatigue in Ductile Materials" ..... August 21, 1958
5. "Interpretation of Fatigue Data for Ductile Materials" ..... September 4, 1958
6. "Elastic Stress Analysis" ..... January 22, 1959
7. "Exact and Approximate Solutions" ..... February 5, 1959
8. "Elastic Stresses by Energy Methods" ..... February 19, 1959
9. "Elastic Stress Solutions" ..... March 5, 1959
10. "Elastic Stresses by Minimizing Residuals" ..... March 19, 1959
11. "Stresses Under Plastic Flow and Creep" ..... July 9, 1959
12. "Plastic Stresses and Strains by Successive Approximations" ..... July 23, 1959
13. "Incremental Solutions for Plastic Stresses and Strains" ..... August 6, 1959
14. "Strain Gage Measurements" ..... October 29, 1959
15. "Strain Gage Applications" ..... November 12, 1959

Other references mentioned in this article are:

16. M. M. Frocht—*Photoelasticity*, Vol. 1, 1941, John Wiley and Sons, New York, N. Y.
17. R. B. Heywood—*Designing by Photoelasticity*, Chapman and Hall Ltd., London, 1952.
18. M. Hetenyi—*Handbook of Experimental Stress Analysis*, John Wiley and Sons, New York, N. Y., 1950.
19. Herbert Tramposch and George Gerard—"Correlation of Theoretical and Photothermoelastic Results on Thermal Stresses in Idealized Wing Structures," *Technical Report SM* 58-8, New York University, September, 1958.
20. George Gerard and Herbert Tramposch—"Photothermoelastic Investigation of Transient Thermal Stresses in Multiweb Wing Structure," *Technical Report SM* 58-9, New York University, October, 1958.
21. George Gerard and A. C. Gilbert—"Photothermoelasticity: An Exploratory Study," *Journal of Applied Mechanics*, Vol. 24, No. 3, September, 1957, p. 355.
22. Philip Reichner—*A Photoelastic Study of Stress Concentration at Multiple Notches in the Rim of a Uniform Thickness Disc, Which is Subject to Rotational and Thermal Stress*, M. S. Thesis, University of Pittsburgh, 1957.
23. Herbert Tramposch and George Gerard—"Plastics for Thermoelastic Investigations," *Journal of Applied Mechanics*, December, 1958, Vol. 25, No. 4, p. 525.
24. S. S. Manson—"Determination of Elastic Stresses in Gas Turbine Discs," *NACA Report* 871, 1947.
25. M. A. Biot—"A General Property of Two-Dimensional Thermal Stress Distributions," *Phil. Mag.*, March, 1935, Ser. 7, Vol. 90, p. 540.
26. N. Muskhelishvili—"On Thermal Stresses in the Plane Problem of the Theory of Elasticity," *Bull. Elec. Tech. Inst.*, St. Petersburg, Vol. 13, p. 23, 1916.
27. E. E. Weibel—"Thermal Stresses in Cylinders by the Photoelastic Method," *Proc. 5th Int. Cong. Appl. Mech.*, p. 213, John Wiley and Sons, New York, N. Y., 1939.
28. M. L. Williams—"Some Thermal Stress Design Data for Rocket Grains," *Jour. Amer. Rad. Soc.*, April, 1959, Vol. 29, No. 4, p. 260.
29. G. Hotchkiss—"Electrosensitive Recording Paper for Facsimile Telegraph Apparatus and Graphic Chart Instruments," *Technical Review*, 1948, Western Union Telegraph Co.
30. S. K. Clark and R. L. Hess—"Transient Thermal Stress by An Analogy," *Jour. App. Mech.*, December, 1958, Vol. 25, No. 4, p. 627.
31. M. M. Leven and R. C. Sampson—*Photoelastic Stress and Deformation Analysis of Nuclear Reactor Components*. Paper presented before SESA Fall meeting, 1958.



Polycarbonate Plastics

. . . new engineering materials

POLYCARBONATE resins are completely new thermoplastic molding compounds. They combine an unusual toughness and heat stability. In addition, they are dimensionally stable and exhibit good electrical properties.

Polycarbonate resins will replace metals in some applications or will be combined with metals. Although the tensile strength of thermoplastics does not approach that of metals, the comparison is favorable when strength-to-weight ratio is considered, Fig. 1*a*.

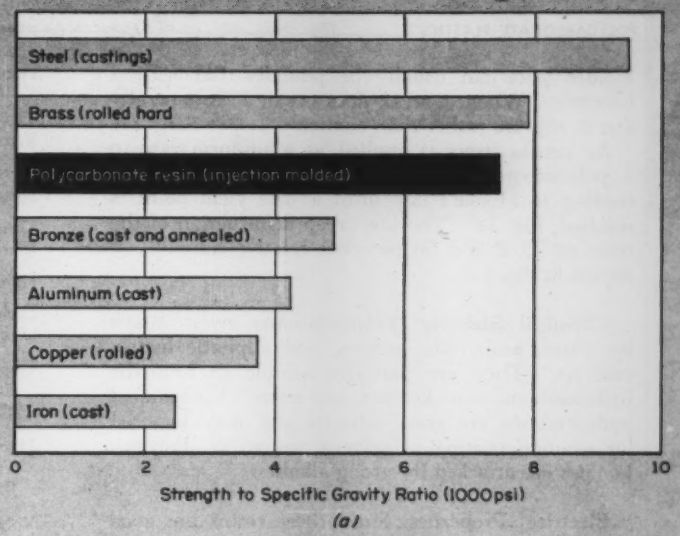
At its current introductory price, polycarbonate resin is cheaper than brass, bronze, and copper on a cost per unit volume basis. When full-scale commercial production is achieved, the resin should be priced competitively with aluminum, steel, and iron.

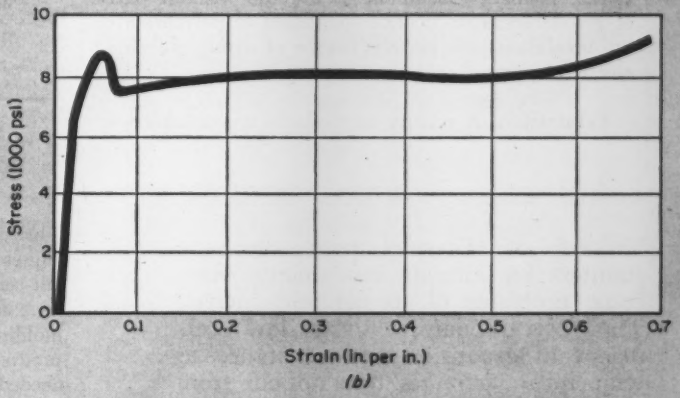
Properties: Generally, a plastic is tough enough to be considered for impact applications if it has a notched Izod value of 1 ft-lb per in. of notch or higher. Most high-impact thermoplastics show a value less than 5. Polycarbonate, however, has an impact strength of 12 to 16 ft-lb per in. and offers exceptional resistance to sharp blows.

Polycarbonate parts actually possess a malleability similar to metals. Depending on the design, a

Coil form must withstand temperatures above 200 F without deformation from stresses exerted by the tightly wound coil. Lexan resin has a heat-distortion temperature of 280 to 290 F under load, is resistant to oxidation at high temperature, and is noncorrosive even when used with very fine Class F magnet wire.

RICHARD J. THOMPSON
Chemical Materials Dept.
General Electric Co.
Pittsfield, Mass.





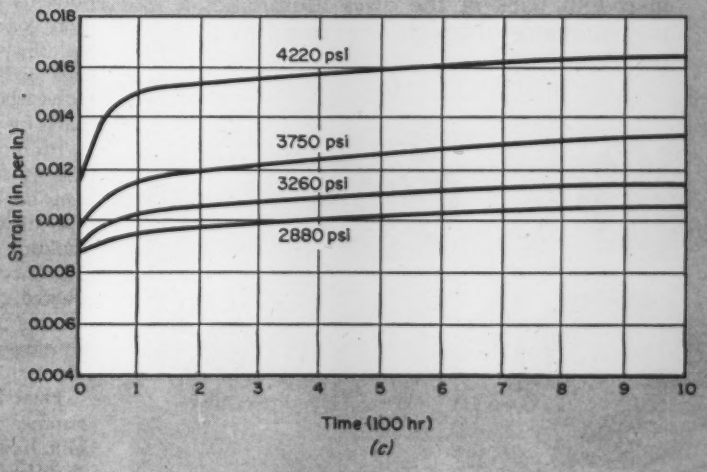


Fig. 1—Strength-to-weight ratio of Lexan polycarbonate resin and some engineering metals, *a;* stress-strain curves, *b,* for polycarbonate; and creep deformation at 73 F and 50 per cent relative humidity, *c.*

molded part can usually be pounded flat with a hammer. When a break does occur, it is generally due to rupture rather than shatter.

As tensile stress is applied at a uniform rate to a polycarbonate part, deformation takes place according to Hooke's law until a true yield point is reached, Fig. 1*b*. The low creep deformation of the resin at 73 F and 50 per cent relative humidity is shown in Fig. 1c.

Chemical Stability: Polycarbonates resist attack by water, acids, oils, greases, and aliphatic hydrocarbons. They are partially soluble in aromatic hydrocarbons, some ketones, and esters. Chlorinated hydrocarbons are good solvents and may be used for solution coating or solvent cementing. Polycarbonates are attacked by strong alkalies.

Electrical Properties: Since these resins are good electrical insulators, Table 1, they may be used to complement the conducting properties of metals. Often, insulating components are the weakest part of an electrical unit. The toughness of polycarbonate insulation now permits design of strong, durable electrical parts.

Fabrication: A variety of methods is available for fabricating polycarbonate. Generally, these techniques are fast, provide ready-to-use parts, and permit reuse of scrap. Injection molding cycles can produce as many as 19,000 parts per hour. Compression molding is possible but is not recommended for production because of the relatively long cycles needed.

Thermoforming may be done by either vacuum or pressure techniques. Solubility in chlorinated solvents permits the use of polycarbonates for solution coating or cast film. Since the resin is available in powder form, it may be applied by the fluidized bed process. The ductility and malleability of polycarbonate make possible the fabrication of some parts by cold forming.

In most cases, polycarbonate parts are ready to use as soon as they are fabricated. Metal inserts can be molded in place to eliminate a secondary operation. Dyes or pigments can be added prior to molding to yield transparent or opaque colored parts. If necessary, parts can be polished, painted, lacquered, or metalized. Polycarbonate stock can be worked with standard metalworking tools, and machining characteristics are similar to those of brass.

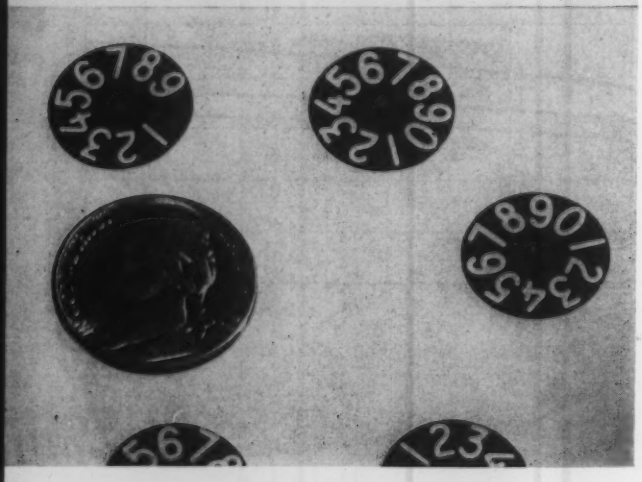
Heat Resistance: Polycarbonate resin has good resistance to thermal oxidative degradation to 300 F and has a heat-distortion point of about 285 F. It is different from other thermoplastics in that its heat-distortion point is not sensitive to loading and is essentially the same at both high and low loading. The resin is rated as self-extinguishing.

Table 1—Properties of Polycarbonate Plastic*

Tensile strength (1000 psi)	8 to 9
Tensile modulus (1000 psi)	320
Flexural strength (1000 psi)	11 to 13
Flexural modulus (1000 psi)	375
Compressive strength (1000 psi)	11
Compressive modulus (1000 psi)	240
Hardness (Rockwell R scale)	118
Dielectric strength, ⅛-in. specimen (v per mil)	400
Dielectric constant,	
60 cycles	3.17
10^6 cycles	2.96
Power factor,	
60 cycles	0.0009
10^6 cycles	0.010
Volume resistivity (ohm-cm)	2.1×10^{16}
Arc resistance (sec),	
Tungsten-rod electrodes	120
Stainless-steel strip electrodes	10 to 11

*Lexan polycarbonate resin.

Molded of Lexan, these disc-type counters for aircraft instruments overcome problems of torque and inertia. The polycarbonate, with its low coefficient of expansion and resistance to temperature extremes, does not cup from the press fit on the shaft and operates satisfactorily from −65 to 225 F. A light placed in back of the discs illuminates the numerals through the translucent portions.



Solving Equations

. . . an easy, quick way to find roots of higher-degree equations. It combines interpolation and Newton's method.

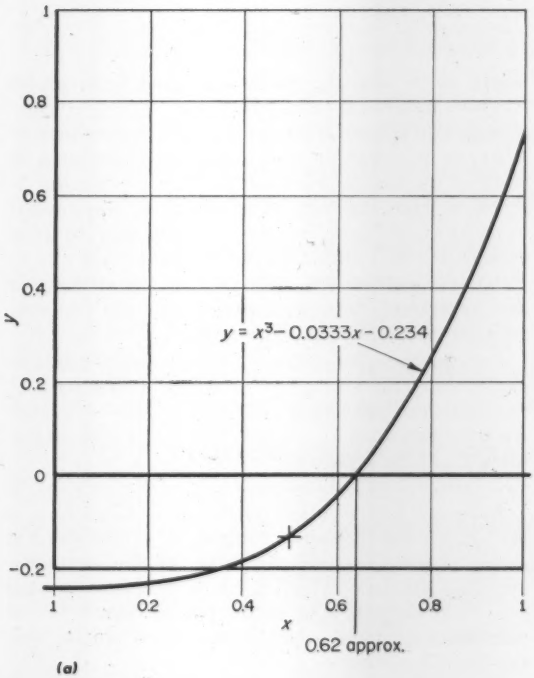
JOHN P. HATCH
Associate Professor of Mechanical Engineering
University of Rhode Island
Kingston, R. I.

PROBLEMS arising in design often require the solution of cubic or higher-degree equations. Haste to get an answer usually leads to cut and try, requiring many trials, rather than more formal or systematic procedures. A good compromise would be a method that gives accurate results quickly and is neither complicated nor hard to remember. One is outlined here. The basic steps are:

1. Sketch a graph to determine rough values of the roots.
2. Base two trial values on the graphical solution and interpolate between them to find a more accurate result.
3. Apply Newton's method to produce another solution.
4. Average the results from interpolation and from Newton's method. The average is usually a sufficiently accurate solution.

This procedure can be best illustrated with a typical problem. Assume that the equation to be solved is $x^3 - 0.0333x - 0.234 = 0$.

Plot the Curve: To get an approximate solution, introduce y to represent $f(x)$. Then, $y = x^3 - 0.0333x - 0.234$. A value of x yielding $y = 0$ is a



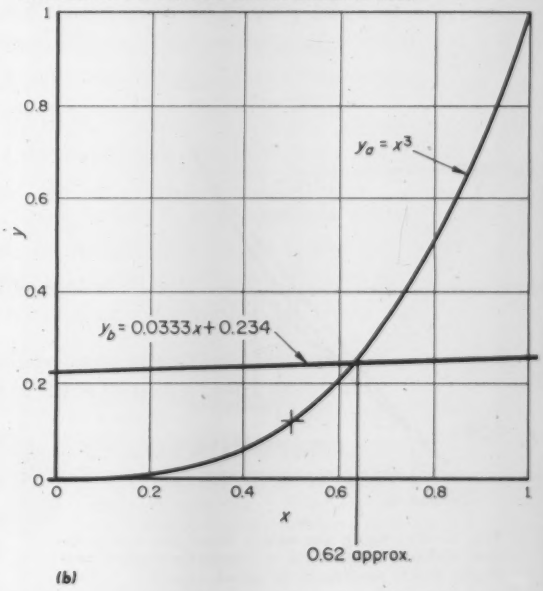


Fig. 1—Finding roots starts with a graphical approximation. For problems such as the one shown, the equation may be rough plotted, *a*, from a few calculated points to determine x at $y=0$. Or, often the equation may be separated into components, *b*, for easier calculation of points. Intersection of the two curves marks a root.

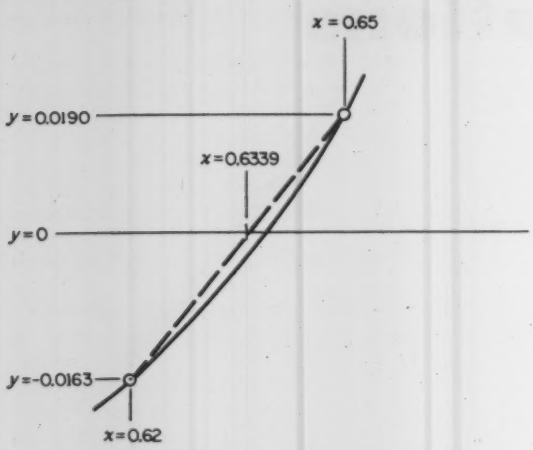


Fig. 2—Linear interpolation gives a closer approximation. The smaller value of x was picked off the graph, the larger value assumed.

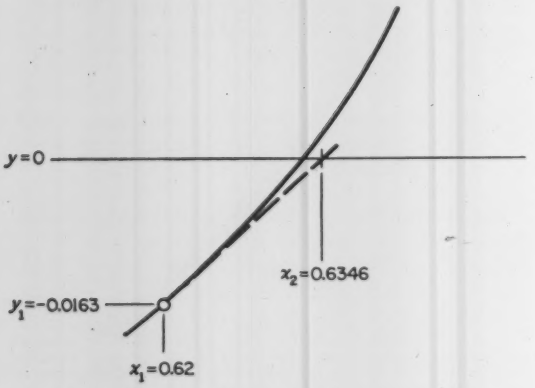


Fig. 3—Newton's method gives another approximation, falling generally on the other side of the true value from that produced by interpolation.

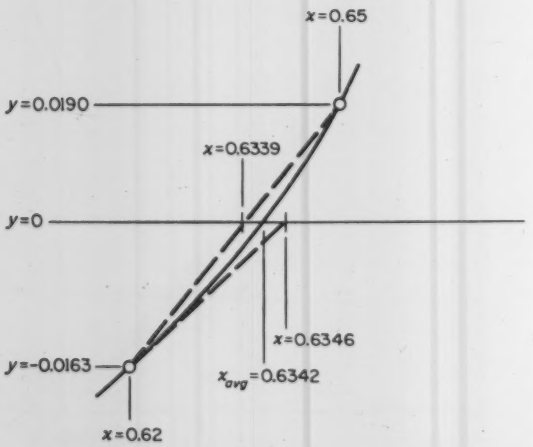


Fig. 4—Averaging the values from one interpolation and one application of Newton's method generally yields results of required accuracy.

solution. The curve of y vs. x may be plotted directly, Fig. 1*a*, or the solution may be simplified by rewriting the equation in two parts. Let $y = y_a - y_b$, corresponding to $y = (x^3) - (0.0333x + 0.234)$. Then, $y_a = x^3$ and $y_b = 0.0333x + 0.234$. The two equations can be plotted separately, Fig. 1*b*. Points of intersection are solutions to the equation because, there, $y_a = y_b$ or $y_a - y_b = 0$; therefore, $y = 0$. Fig. 1*b* shows $x \approx 0.62$.

An accurate plot on graph paper should produce a root correct to about 1 per cent. Even a rough plot sketched on plain paper should produce a root within 5 per cent of the correct value. Roots discovered on the graph should be inspected to determine which have physical significance.

Interpolate: Using the root found graphically, determine the value of $y = f(x)$. If it is not equal to zero, choose an appropriate larger or smaller value and try again. If these two trials produce one positive and one negative value, then interpolate to find a value of x for the third trial. If both values are positive or negative, extrapolate, of course, to find a third value.

Solving for y with $x = 0.62$ yields $y = -0.0163$. Next, try $x = 0.65$. This time, $y = 0.0190$. The third value can be calculated by linear interpolation: $x = 0.6339$. Results are displayed in Fig. 2.

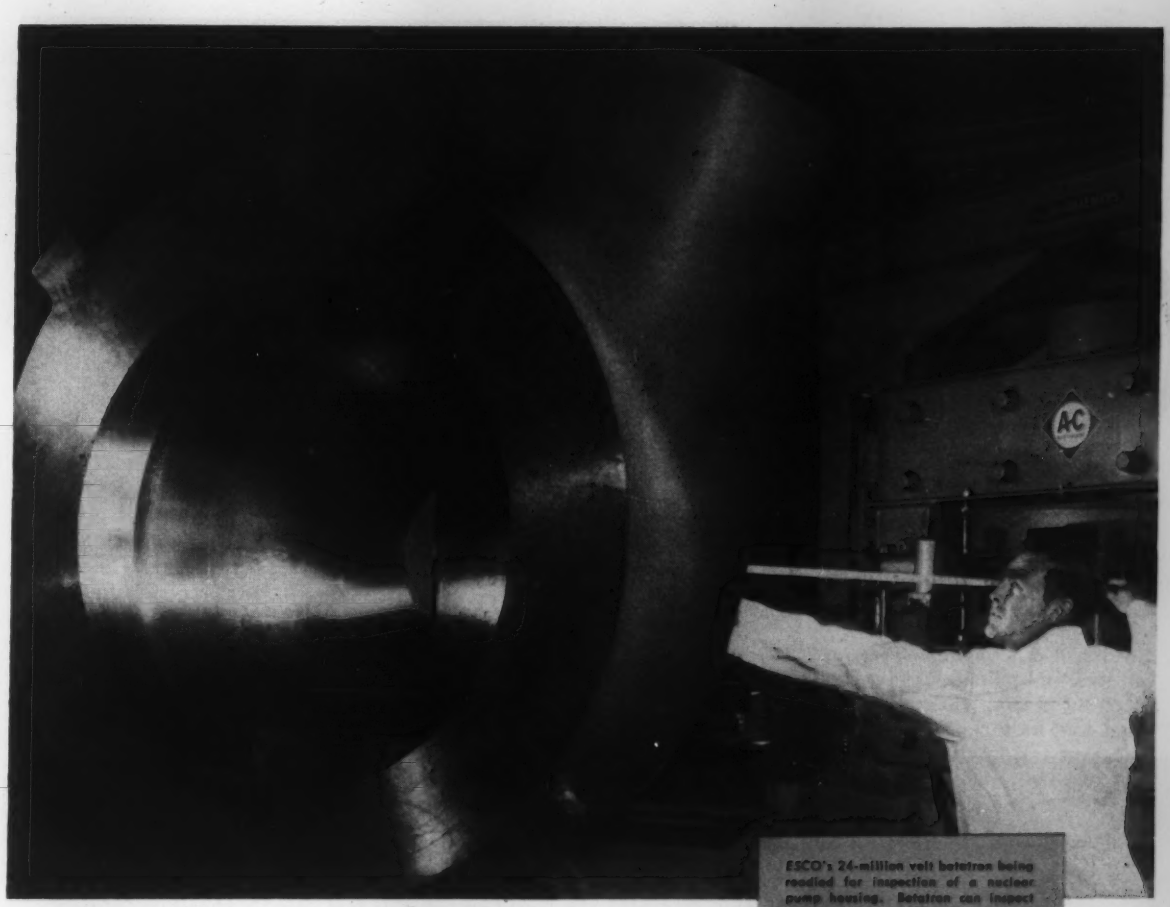
Apply Newton's Method: Starting from an estimated value for x, Newton's method, Fig. 3, leads to a closer approximate value. That value is simply the intersection of the curve tangent at the first value and the x axis. The x value so determined can then be used in the same fashion to find another closer value, and so on. Algebraically,

$$x_2 = x_1 - \frac{f(x_1)}{f'(x_1)} \qquad (1)$$

where x_1 = starting value estimated from graph, $f(x_1)$ = numerical value of y for x_1, $f'(x_1)$ = value of first derivative for x_1, x_2 = next approximation. After x_2 is found, it may then be substituted in place of x_1, and x_3 determined. This process can be repeated and the root determined to any degree of accuracy. Often, however, results will be close enough if one solution by interpolation and one by Newton's method are averaged. A convenience is that several of the computation steps are common, with common values, to both methods.

For the sample problem, data already available are $x_1 = 0.62$ and $y_1 = -0.163$. Differentiating the equation leads to $y' = f'(x) = 3x^2 - 0.0333$. By substitution of $x_1 = 0.62$, $f'(x) = 1.120$. Evaluating Equation 1 gives $x_2 = 0.6346$.

Average: Interpolation produced a solution of $x = 0.6339$; by Newton's method, $x = 0.6346$. The actual value lies between, close to the average—probably about 0.6342, Fig. 4. If this answer were not close enough, the entire process could be repeated, or perhaps interpolation alone would yield the desired accuracy.



ESCO's 24-million volt betatron being readied for inspection of a nuclear pump housing. Betatron can inspect a six-inch steel wall section in 60 seconds, a 14-inch wall in 1½ hours.

design problems can be simplified with

ESCO'S nuclear casting know-how

Solving tough casting problems has always been *ESCO*'s specialty. And that's why *ESCO* has been furnishing nuclear castings right from the start of the atomic energy program. Nuclear casting specifications and inspection requirements are thoroughly understood at *ESCO*.

ESCO has the facilities, as well as the technical know-how, for critical, exacting, casting jobs. Centrifugal, shell or static casting methods produce castings weighing several tons, or less than a pound, in more than 90 steel alloys. Testing facilities include X-ray, gamma ray, spectrograph, zyglo, dye penetrant, magnetic particle and betatron inspection, as well as complete chemical and mechanical laboratories.

Make an appointment with an *ESCO* metallurgical engineer today. He may be able to simplify and help solve your designing problems.

ESCO

ELECTRIC STEEL FOUNDRY COMPANY

2183 N. W. 25TH AVE. • PORTLAND 10, OREGON

MFG. PLANTS AT PORTLAND, ORE. AND DANVILLE, ILL.

Offices in Most Principal Cities

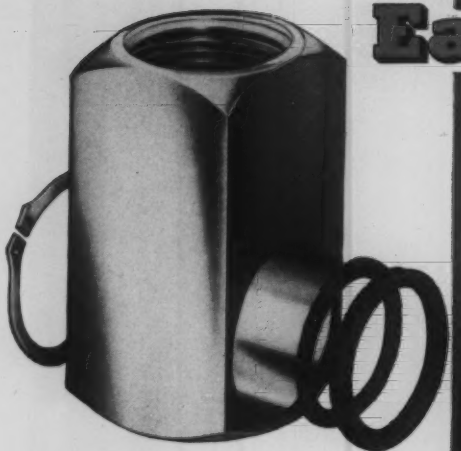
ESCO INTERNATIONAL, NEW YORK, N. Y.

IN CANADA ESCO LIMITED

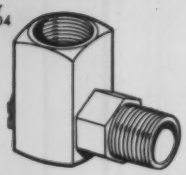
Circle 481 on Page 19

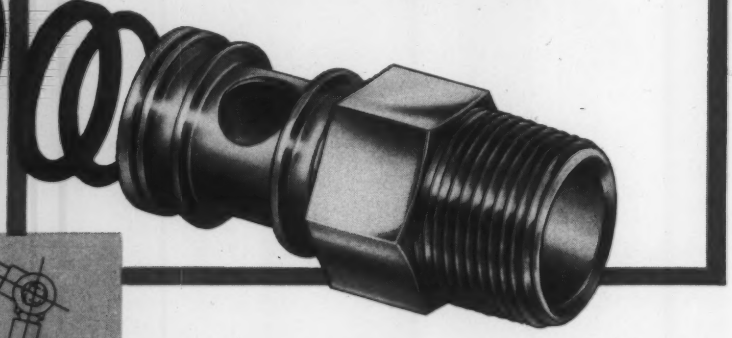
Eastman offers INDUSTRIAL SWIVEL CONNECTOR

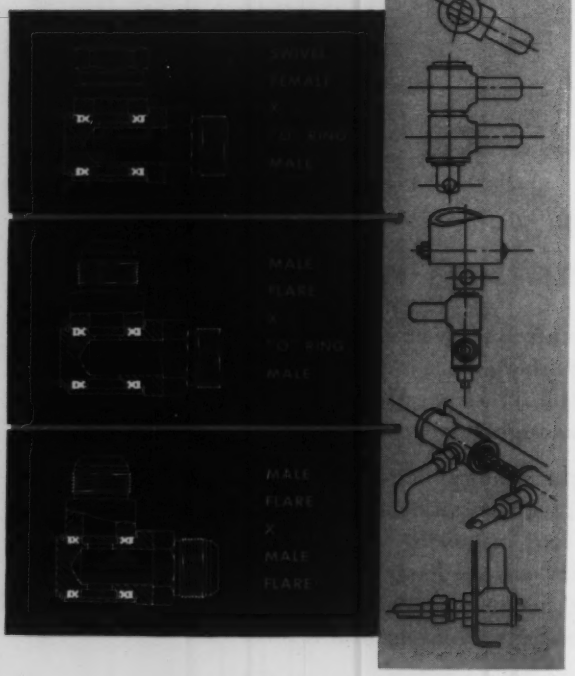
to eliminate hydraulic hose failure under severe flexing

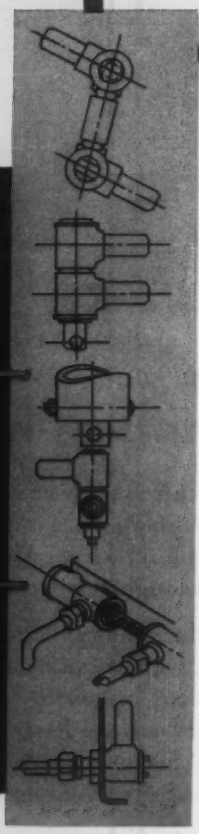


Licensed Under Pat. No. 2481404









If you have been designing "around" metal swivel joints because of high cost, EASTMAN now offers an economical swivel connector for industrial use—precision engineered to assure adequate freedom of motion—proved under the most rigid government requirements.

Unique design assures "balanced" flow of hydraulic fluid at required pressure—at any angle. Fluid pressure is also balanced by a *double seal* assembly at each end of stem. Pressure-Balance assures equal internal pressure, causing the body to float about the stem, free of end load and friction.

Eastman Swivel connectors will make your flexing installations the most reliable link in your Hydraulic Assembly.

APPLICATIONS:
For use on Cranes, Loaders, Earth Moving Equipment, Hydraulic Presses, Shears, etc.—wherever unusual flexing and exposure may shorten hose life or cause premature failure and frequent replacement.

ECONOMY:
Permits use of shorter hose lengths since less hose allowance is needed for complete extension. Shorter lengths of longer lasting, multiple spiral wire high pressure hose may be used, since Swivel Connector absorbs flexing motion.

ADAPTABILITY:
Body of Connector available with any combination of ends. Now available in types and sizes shown at left. Various combinations of stems can be interchanged with any body style.

WRITE, WIRE or CALL about Eastman Swivel Connector Opportunities in Your Line.

STANDARD SIZES AND COMBINATIONS AVAILABLE

●

LOW TORQUE—Freedom from friction, even under high pressure.

WIDE RANGE—Operating pressures up to 5000 PSI. Trouble-free operation through wide temperature range.

ROTATION—Full 360° for all manifolds.

SIZES—Steel, plated for corrosion protection—½" thru 1½".

Eastman
first in the field
MANUFACTURING COMPANY
Dept. MD-11, MANITOWOC, WISCONSIN

SAFEGUARDING AMERICA'S LIFELINES OF MOBILE POWER

Circle 482 on Page 19

Flexible Hose for Hydraulic Systems

Characteristics to guide the selection of current types, and a brief look into the future.

D. WENDELL FENTRESS
Vice-President
Research and Development
Flexonics Corp., Elgin, Ill.

COMMERCIAL flexible hose for hydraulic systems may be divided into two principal types: Metal and synthetic. Metal hose may be fabricated from practically any alloy sufficiently ductile to form either helical or annular corrugations to appropriate depth, section shape, and pitch. Synthetic hose may be manufactured from a large number of elastomeric or rubber-like compounds and polymeric or plastic compounds. Types of hose may be further differentiated by construction, reinforcement, kinds of fittings and fitting methods.

Construction: Structural parameters for metal hose include wall thickness, convolution form, and reinforcement. Convolution details include depth, pitch, and shape, either helical or annular. Factors in flexibility are wall thickness, corrugation height, and number of convolutions per unit length. In multiple-ply construction, flexibility varies as the sum of the squares of each ply thickness. In synthetic hose, structural parameters are a combination of inner tube, reinforcement, and cover. As operating pressures increase, braid does too.

Reinforcement: Usually, reinforcement on flexible-metal hose is wire braid. The main function of reinforcement is to provide end-load restraint, and thus prevent elongation of hose under pressure. Variables of reinforcement include diameter and number of braid wires, braid angles, per cent coverage, and materials.

In synthetic hose, an additional function of reinforcement is to withstand hoop or radial stresses. Reinforcement may consist of wire braid, fiber braid, or combinations of wire and fiber braids. Reinforcement may be used as a cover or it may be embedded in the synthetic.

Fittings: Types of end fittings for both metallic and nonmetallic hose include threaded nipples, swivel nuts, flanges, and weld ends. Method of attachment is a main design consideration. On metal hose, fittings may be attached mechanically or by welding, brazing, or soldering. Synthetic hose fittings are commonly attached by swaging, crimping, or mechanical screw-on. In all cases, the method involves compressing the resilient wall of the hose between inner and outer cylindrical bodies. Selection depends on temperature, pressure, and mediums.

Pressure: Probably the first consideration in selection of hose is pressure. Normally, hose is designed with a safety factor of at least four to one. Typical burst pressures are shown in Table 1.

A severe operating condition for hydraulic lines is hydrostatic shock loading caused, for example, by rapid operation of valves or sudden stops of hydraulic-actuated equipment. Fig. 1 indicates the pressure curve required to satisfy specification MIL-H-8788. In synthetic

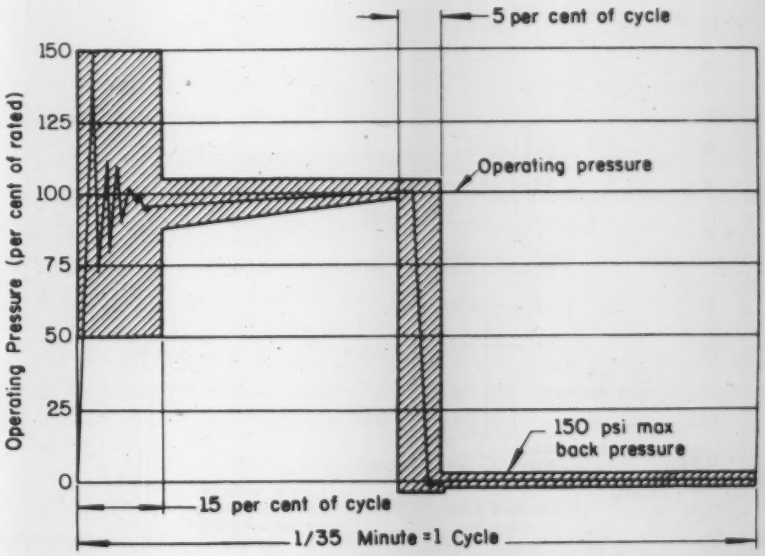


Fig. 1—Pressure-time cycle for impulse testing of hydraulic hose. Slopes of curves indicate rate of pressure rise or fall. Performance confined to shaded area assures valid comparison and interchangeability of hydraulic components.

hose, inherent resilience helps to absorb shock loading. Metal hose absorbs shock loads by breathing action of the convolutions.

Temperature: In general, metal hose is less restricted by temperature parameters than is synthetic hose. At high temperatures, performance of flexible metal hose roughly parallels performance of its alloys.

Synthetic rubber hose deteriorates at temperatures over 250 F, and cracks below −40 F. Teflon may be used from −300 F to 500 F. Below −100 F, Teflon becomes stiff.

Mediums Conveyed: The only synthetic which is resistant to most mediums is Teflon. In fact, Teflon is attacked only by molten alkali metals and by fluorine at high temperatures and pressures. However, since a hydraulic hose assembly usually has metallic end fittings, the resistance of the assembly to the mediums must be considered rather than the resistance of the hose alone. Metal hose is subject to corrosion, of course. Alloys selected must be fully resistant to the mediums. Selection of inside material with respect to mediums applies in like manner to outside materials with respect to environments.

Table 1—Typical Burst Pressures for Hydraulic Hose

Hose Type:	Synthetic			Metal		
Pressure Rating:	Low	Med.	High	Low	Med.	High
Reinforcement (Braids):	2 Fiber	1 Fiber 1 Wire	2 Wire	1 Wire	1 Wire	Spiral Wrap
OD (in.)	Pressure (psi)					
¼	5,000	12,000	20,000	12,700	18,600	31,000
⅜	4,500	9,000	16,000	6,700	13,800	25,700
½	4,000	8,000	14,000	5,870	12,400	27,500
¾	3,000	6,000	9,000	4,600	8,200	17,500
1	2,250	3,200	7,500	2,580	6,250	....
1¼	1,500	2,500	6,500	1,970	5,200	....
1½	....	2,000	5,000	1,680	4,350	....
2	....	1,400	4,500	1,920	3,540	....

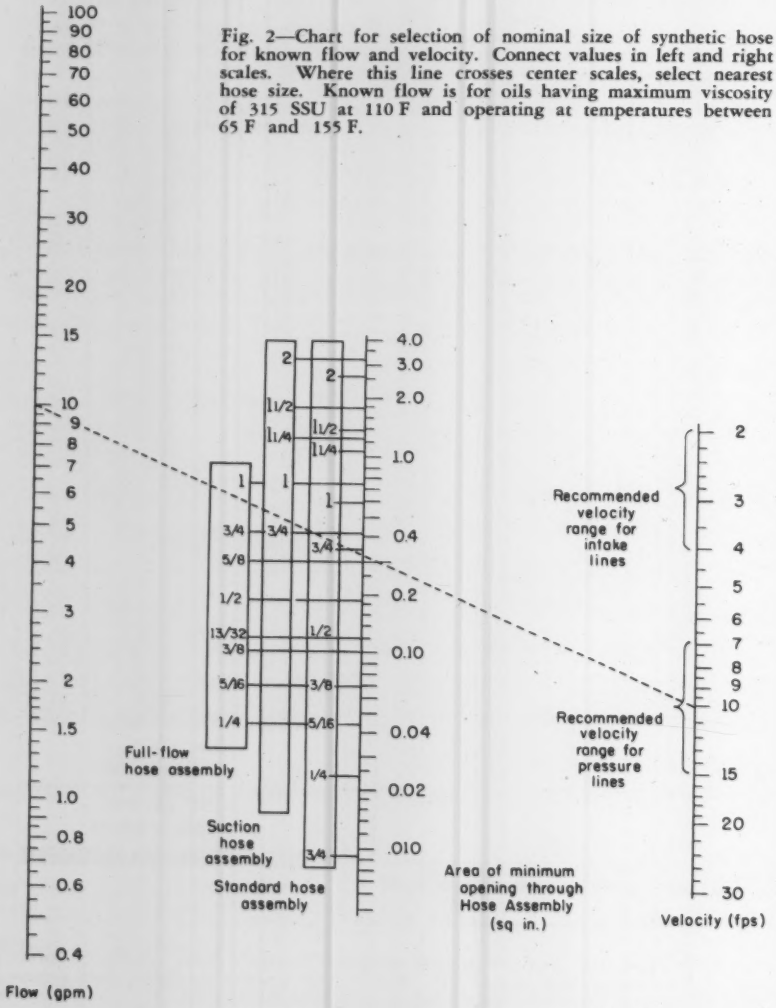

Flow (gpm)
Full-flow hose assembly
Suction hose assembly
Standard hose assembly
Area of minimum opening through Hose Assembly (sq in.)
Recommended velocity range for intake lines
Recommended velocity range for pressure lines
Velocity (fps)

Fig. 2—Chart for selection of nominal size of synthetic hose for known flow and velocity. Connect values in left and right scales. Where this line crosses center scales, select nearest hose size. Known flow is for oils having maximum viscosity of 315 SSU at 110 F and operating at temperatures between 65 F and 155 F.

Motion: If motion is encountered during the service life of a flexible hose, it must be bending motion to assure adequate fatigue life. In no case should the installation be designed to provide for axial motion (compression or extension) nor should torque be imposed upon the assembly.

Flow: Extensive testing has established that the pressure drop through a corrugated hose, depending upon configuration of the convolution, varies between two and three times that of smooth-wall tubing. The nomograph in Fig. 2 may be used to determine the size of synthetic hose.

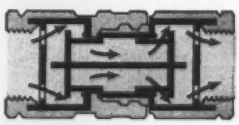
Specifications: Military Specifications on synthetic hose include MIL-H-8794 (formerly MIL-H-5511) on medium-pressure rubber hose, MIL-H-8788 (formerly MIL-H-5512) on high-pressure rubber hose, and MIL-H-25579 on medium-pressure Teflon hose. SAE Specifications on synthetic hydraulic hose, SAE 100R1 through SAE 100R5, cover the same general parameters as do Military Specifications but are less demanding. SAE specifications on metal hose are Aircraft Recommended Practices, ARP 601 and ARP 602. ARP 604, in preparation, will cover requirements for Teflon hose at high pressures.

Future Requirements: Trends in hydraulic systems, particularly for aircraft and missiles, indicate conditions of 6000 psi and 800 F.

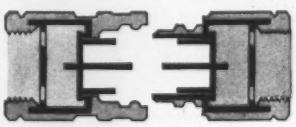
Ever-increasing emphasis on reliability is being met by spiral-ply synthetic hose construction. Spiral-

There's a size and type to handle almost anything that flows

TO USE SNAP-TITE VALVED COUPLING:



CONNECT—Full flow instantly



DISCONNECT—No flow instantly

Snap-Tite can provide the right size valved coupling for most any use . . . with quick off-on action wherever coupling or shut-off is required.

"H" series valved couplings for high pressure applications. High resistance to heavy line surge. Sizes from 1/8" through 6". Larger sizes on special order.

"IH" series valved couplings for greater impact in air lines. 1/8" through 1/2".

"E" series valved couplings for vacuum and very low pressure. Recommended for gravity flow. Sizes from 1/8" to 6". Larger sizes on special order.

"T" series valved couplings for hard to handle fluids. The only valved quick-disconnect couplings now on the market for fluid temperatures from −40°F to +400°F. Sizes from 1/2" through 3".

Snap-Tite valved couplings are available with two-way or one-way automatic line shut-off. They are normally furnished in alloy steel. Also available in brass, aluminum, or stainless steel with a variety of finishes.

Write for Snap-Tite Catalog No. 58 for more information on Snap-Tite valved couplings.

★Snap-Tite

UNION CITY 11, PA.

ST-59-02

When the job calls for "gearhead motor"

cost-wise designers specify

BOSTON Gear® OPTIMOUNT®

HELICAL GEARED RATIOMOTORS

Add up the SAVINGS and see why . . .

YOU SAVE DESIGN TIME. Optional mounting gives full scope to your designing skill. Drive arrangements are not restricted by the mounting limitations of conventional gearhead motors.

YOU ELIMINATE EXTRA COST OF SPECIALS. With OPTIMOUNT Ratiomotors FROM STOCK, you can meet hundreds of unusual drive conditions that would require "specials" in conventional gearhead motors. You save the delay and extra cost.

YOU REDUCE PARTS COST. Since OPTIMOUNT offers a choice of many output shaft positions, you can design for direct lineup — and eliminate extra couplings, bearings, and other parts needed to "hook up" a conventional gearhead motor.

YOU SPEED PRODUCTION. Order the OPTIMOUNT you need with a phone call to your local Distributor, for delivery FROM STOCK. You can start production without delay, maintain schedules, and avoid big inventory expense.

YOU SIMPLIFY SERVICING. All OPTIMOUNT components are standardized stock parts — available promptly from over 100 BOSTON Gear Distributors throughout the U. S. and Canada.

Ask your BOSTON Gear Distributor for complete information. Boston Gear Works, 64 Hayward St., Quincy 71, Massachusetts.

VERTICAL BASE MOUNTED OPTIMOUNT RATIOMOTOR drives agitator blade shaft on pigment mixers in coated textiles plant. Manufacturer says: "OPTIMOUNT adaptability permitted simplified, efficient design for our specific needs . . . at a much lower cost for the complete installation."

Meet any in-line drive mounting conditions with STANDARD STOCK models

Vertical or horizontal base mounted — for any floor, wall, or ceiling mounting position — choice of many shaft positions in either base — single or double reduction helical gearing — for ¼ to 10 hp drives. Sold also without motor, ready for attachment of separately purchased motor of your choice.

Order from your nearby Distributor and get any arrangement you specify — ready to install

FROM STOCK! at factory prices

Horizontal base mounted

Ask for Catalog No. 57

CALL YOUR NEARBY

BOSTON Gear® DISTRIBUTOR

— STANDARDIZATION PAYS —®

Advt. copyright by Boston Gear Works

Circle 484 on Page 19

ply reinforcement eliminates stress concentrations where braids cross. Addition of basket-weave braid over spiral reinforcement improves the holding power of the fitting but may cause braid failure under impulse conditions.

In the technique for fabricating metal hose, heavier walls which could be corrugated in high-strength alloys have been fabricated into flexible tubing. This has been achieved with a minimum of metal thinning and uniformity of convolution profile.

It is well known that certain of the copper alloys as well as aluminum and magnesium have relatively high damping capacity. This characteristic has been applied to multiple-ply hose assemblies with excellent results. Testing conformed with proposed SAE document ARP 603. Rate of pressure rise of initial impulse has been maintained above 200,000 psi per sec. Peak impulse pressure under these conditions was 4500 psi. The hose was three-ply corrugated type with conventional high-strength alloys for inner and outer plies and a middle ply of an alloy of high damping properties.

Presented at the National Conference on Industrial Hydraulics, sponsored by Armour Research Foundation of the Illinois Institute of Technology, Chicago, October 1959, 13 *pp.*

How to Deliver An Oral Report

ROGER P. WILCOX, GM Institute

TIPS on the organizaton and delivery of an oral technical report. Speakers should observe basic differences between oral and written communications. Evaluation is aided by a questionnaire:

Introduction

Did the speaker effectively capture the interest and attention of his group right from the start?

Did the speaker give the necessary explanation of the background from which the problem derived?

Did the speaker clearly state and explain his problem?

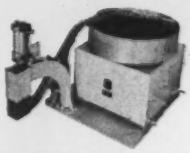
Did the speaker indicate the method(s) used to solve the problem?

Did the speaker suggest the order in which he would report?

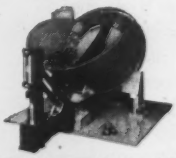
Organization

Was the plan of organization recognizable through the use of:

1. Sufficient introductory information.



VIBRATORY FEEDER for light, fragile or highly finished parts.



ROTARY FEEDER for high production feeding.

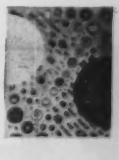
ROTARY HIGH SHELL FEEDER for maximum holding capacity.

Shuffle and deal parts for automatic assembly with

DPS selective feeders

It takes fast, automatic feeding to satisfy the appetites of today's automatic assembly machines. And nowhere can you duplicate the range of equipment, the specialized experience in selective feeders offered by Detroit Power Screwdriver Company.

The most complete line in industry, DPS parts feeders include rotary, vibratory and elevator types. They handle any product from the tiniest of screws to assembly components the size of your fist . . . range in holding area from eighty cubic inches to 20 cubic feet.



DPS will welcome an invitation to analyze your assembly operations. If lagging production can be traced to inefficient feeding, the problem is as good as answered. Write for catalog on selective feeders.

DETROIT POWER SCREWDRIVER COMPANY 15,038

2801 W. Fort St. • Detroit 16, Michigan

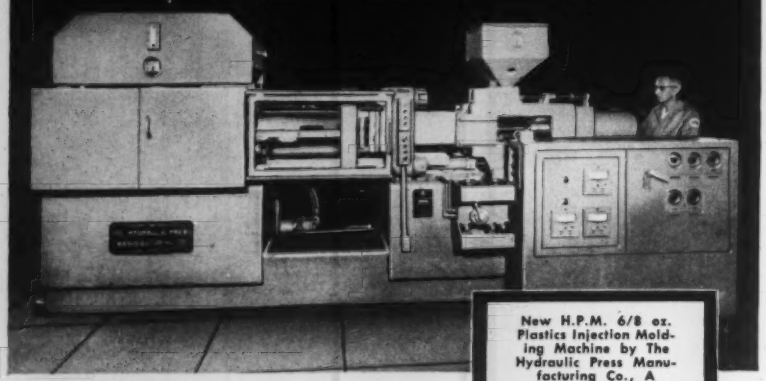
A Subsidiary of Link-Belt Company

Circle 485 on Page 19

Young

HIGH PRESSURE HEAT EXCHANGER

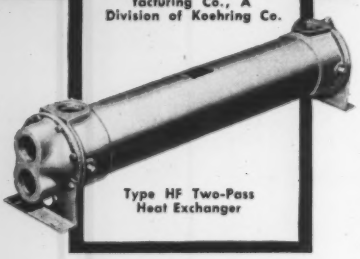
Solves Cooling Problems on High Speed Injection Molding Machine!



New H.P.M. 6/8 oz. Plastics Injection Molding Machine by The Hydraulic Press Manufacturing Co., A Division of Koehring Co.

Young Model HF

Heat Exchanger cools Hydraulic Fluid under high pressures



Type HF Two-Pass Heat Exchanger

Built for the packaging and like industries, this new high-speed plastics injection molding machine has a tremendous capacity. Full clamp stroke at 720 cycles per hour, and as many as 900 cycles per hour with reduced stroke. Continuous operation at such high speeds is made possible by the use of a Young Type HF (High Pressure) heat exchanger which keeps the hydraulic fluid at the correct temperature for most efficient operation. One of over 400 standard models, a Young Type HF Heat Exchanger is used here for working pressures of 150 psi on the tube side and 250 psi on the shell side, at maximum temperature ratings of 350F. Besides having over 400 "stock answers" to heat transfer problems. Young designs and builds special heat exchangers to meet any requirements.

Write Dept. 309-L for Catalog No. 1258

Young RADIATOR COMPANY

RACINE, WISCONSIN

Creative HEAT TRANSFER ENGINEERS

Executive Office: Racine, Wisconsin, Plants at Racine, Wisconsin, Mattoon, Illinois

2. Successful use of transitions from one main part to the next and between points of the speech.
3. Appropriate use of summary statements and restatements?

Were the main ideas of the report clearly distinguishable from one another?

Was there a recognizable progression of ideas that naturally led to the conclusion?

Content

Did the speaker have adequate supporting data to substantiate what he said?

Was all the content meaningful in terms of the problem and its solution? (Avoidance of extraneous material.)

Did the speaker present his supporting data understandably in terms of the ideas or concepts he was trying to communicate?

Were the methods of the investigation clearly presented?

Visual Aids

Did the speaker effectively use charts, graphs, or diagrams to present his statistical data?

Conclusion

Did the speaker conclude his report with finality in terms of one or more of the following:

1. The conclusions reached?
2. The problem solved?
3. The results obtained?
4. The value of such findings to the corporation or industry at large?
5. Recommendations offered?

The Question Period

Did the speaker give evidence of intelligent listening in interpreting the questions?

Were the speaker's answers organized in terms of a summary statement, explanation, and supporting example?

Did the speaker show freedom in adapting or improvising visual aids in answering questions?

Delivery

Did the speaker use a natural, communicative delivery?

Did the speaker use adequate eye contact in maintaining a natural, communicative delivery?

Did the speaker use sufficient movement and gestures?

Did the speaker use good clear diction to express himself?

Could the speaker be heard easily by everyone?

Was the speaker confident and convincing?

Did the speaker display enthusiasm when communicating his ideas?

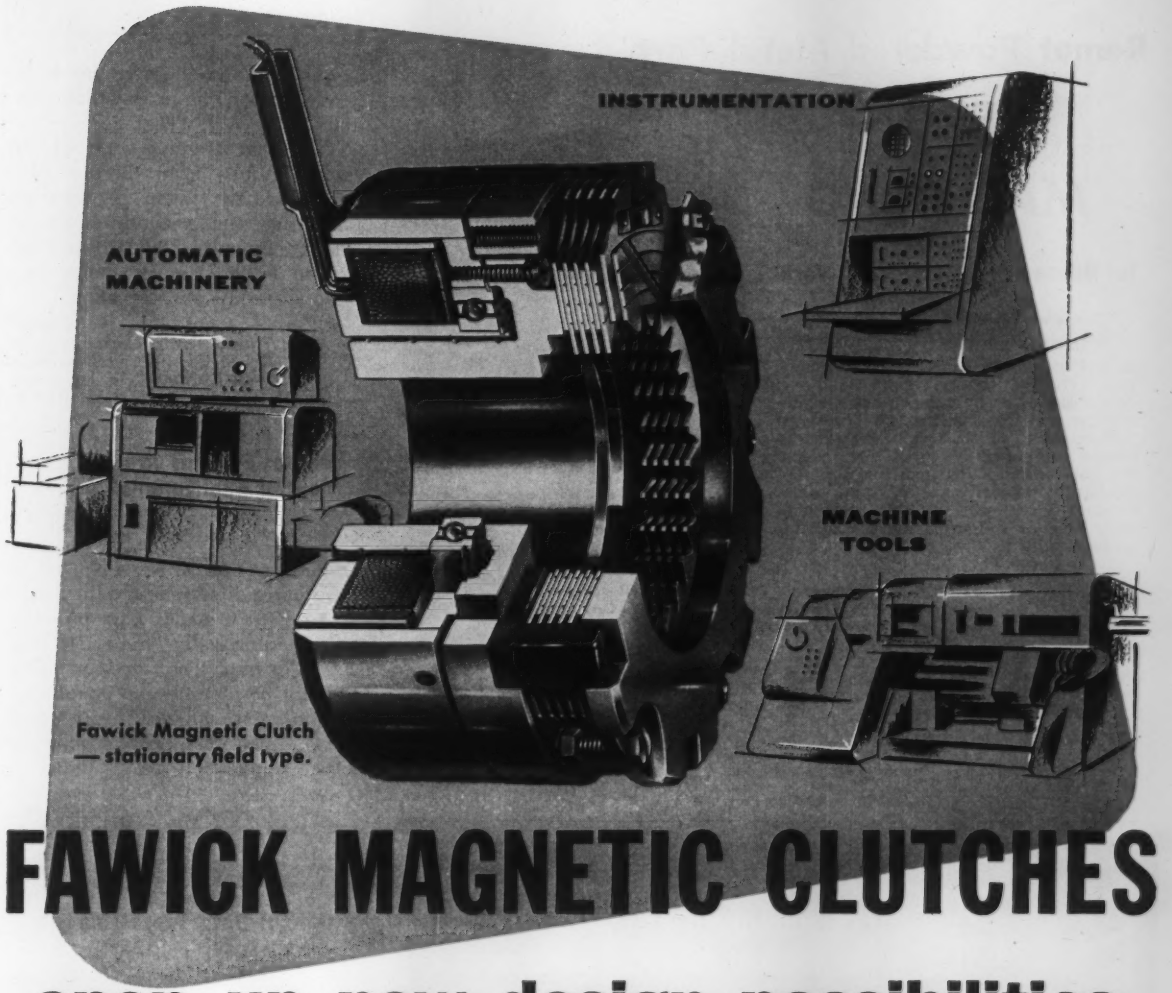
"Characteristics and Organization of the Oral Technical Report," *General Motors Engineering Journal, Vol. 6, October-November-December,* 1959, *pp.* 8-12.

mechanical

Intermittent-Action Camera Absolute-Time Calibrated

G. Hefley, R. H. Doherty, and E. L. Berger, National Bureau of Standards

A recording system which will simultaneously photograph randomly occurring events and the precise time of each event. The system employs a camera which has a minimum consumption of film but can complete a framing cycle in seven milliseconds. The timing system is capable of resolving time to within a few microseconds. When the standard time broadcasts of WWV are used to synchronize the



FAWICK MAGNETIC CLUTCHES

open up new design possibilities

Forward-thinking designers can provide advanced clutch-and-brake performance for their products-of-tomorrow by using FAWICK Magnetics. These electric clutches and brakes offer unmatched advantages for modern high-speed, stop-and-start machinery.

optimum controllability—accurate response to controls with full power transmitted instantaneously. Controls can be local or remote, manual or automatic (push button, relay or limit switch).

trigger-quick action—elimination of residual magnetic drag, and minimum "decay time" assure fast acceleration and high cyclic rates. Engagement is smooth and shock-free. No axial thrust.

space-saving design—compact envelope fits limited space requirements. Self-contained clutches feature largest bore with shortest axial length.

life-time dependability—extra-long life in wet or dry operation assured by excellent heat dissipation, careful material selection and precision production.

FAWICK Magnetic Clutches and Brakes are available in sizes from 2 to 13 inches diameter with torque ratings from 36 to 48,000 in.-lbs. Write for Bulletin M-101 or contact your nearest FAWICK representative.

FAWICK AIRFLEX DIVISION
FAWICK CORPORATION
9919 CLINTON RD. • CLEVELAND 11, O.
In Canada, Fawick Canada, LTD., Toronto

FAWICK Magnetic
INDUSTRIAL CLUTCHES AND BRAKES

Circle 487 on Page 19

Remet Powdered Metal Part
cuts
DESIGN
and
MACHINING
costs
for Bonney Forge and Tool Works

R. L. Huston, Chief Engineer for Bonney, says, "We went to a powdered metal part on our shifter because the cost of machining this part from steel would have been prohibitive. Also, we would have had to change the entire design of our ratchet. We contacted no less than a dozen fabricators of powdered metal. Reese Metal Products Corp. was the only establishment able or interested in tackling this problem with us."

Bonney now uses Remet shifters in seven of their ratchets. The sintered Remet parts are copper infiltrated iron.

More and more design and production men each year rely on Remet services to help solve problems.

FREE BROCHURE "How to Cut Precision Parts Cost with the Remet Powdered Metal Process" shows how the Reese Corp. can help you. Send for your copy today.

Remet
REESE METAL PRODUCTS CORPORATION
537 Howard Ave., Lancaster 10, Penna.

Gears • Pinions • Cams • Ratchets
"Oilless" Bearings • Bushings • Machine and Structural Parts in
COPPER • BRASS • IRON • ALLOY STEEL • NICKEL SILVER • COPPER INFILTRATED IRON

Circle 488 on Page 19

ARE YOU USING THE LATEST EDITION OF YOUR INDUSTRY'S MOST COMPLETE DESIGN AND PRODUCTION HANDBOOK?

The most frequently used reference for design and manufacturing data. For 45 years "The Bible of the Mechanical Industries." Over 1,250,000 copies sold.

New 16th Edition — 1959 — Enlarged and revised, with 192 pages added and over 500 completely new pages of information.

Latest, most accurate data — The proven data you need. Covers the principles, practices and up-to-date standards of design and manufacture you use every day on the job.

Compact, convenient, comprehensive — The 2104 pages of MACHINERY'S HANDBOOK put the facts at your fingertips in one easy-to-use, thumb-indexed volume.

Order your copy today!
$11.00

THE INDUSTRIAL PRESS, 93 Worth Street, New York 13, N. Y.

☐ Please send me _____ copies of the 16th Edition of MACHINERY'S HANDBOOK
☐ Enclosed is full payment; send postpaid. (Add 50¢ outside U.S. & Canada)
☐ Send under 5-day free inspection plan. (U.S. & Canada only)
☐ Please send illustrated folder and booklet giving more information.

Name _____

Address _____ City _____ State _____

system, the absolute accuracy is dependent upon the propagation variables of the WWV signal.

The high framing rate of the camera results from the use of a unique clutch system between the film drive and a continuously revolving flywheel. The clutch actuation mechanism is similar to a large electrodynamic speaker.

IRE paper presented at the Western Electronic Show and Convention (WESCON), August, 1959, and published in 1959 IRE WESCON Convention Record, Part 6, pp. 129-135.

Digital Systems in Control Applications

I. L. Auerbach
Auerbach Electronics Corp.

Underlying principles involved in translating dimensional data from a drawing to a metal part produced on a numerically controlled machine. Examples are given of point-to-point positioning and contouring, and systems engineering concepts are outlined. Practical examples of digital application are included.

ASME paper 59-MD-9, Design Engineering Conference, Philadelphia, May, 1959; 7 pp.

techniques

Optical Data Processing

L. J. Cutrona, E. N. Leith, and L. J. Porcello, University of Michigan

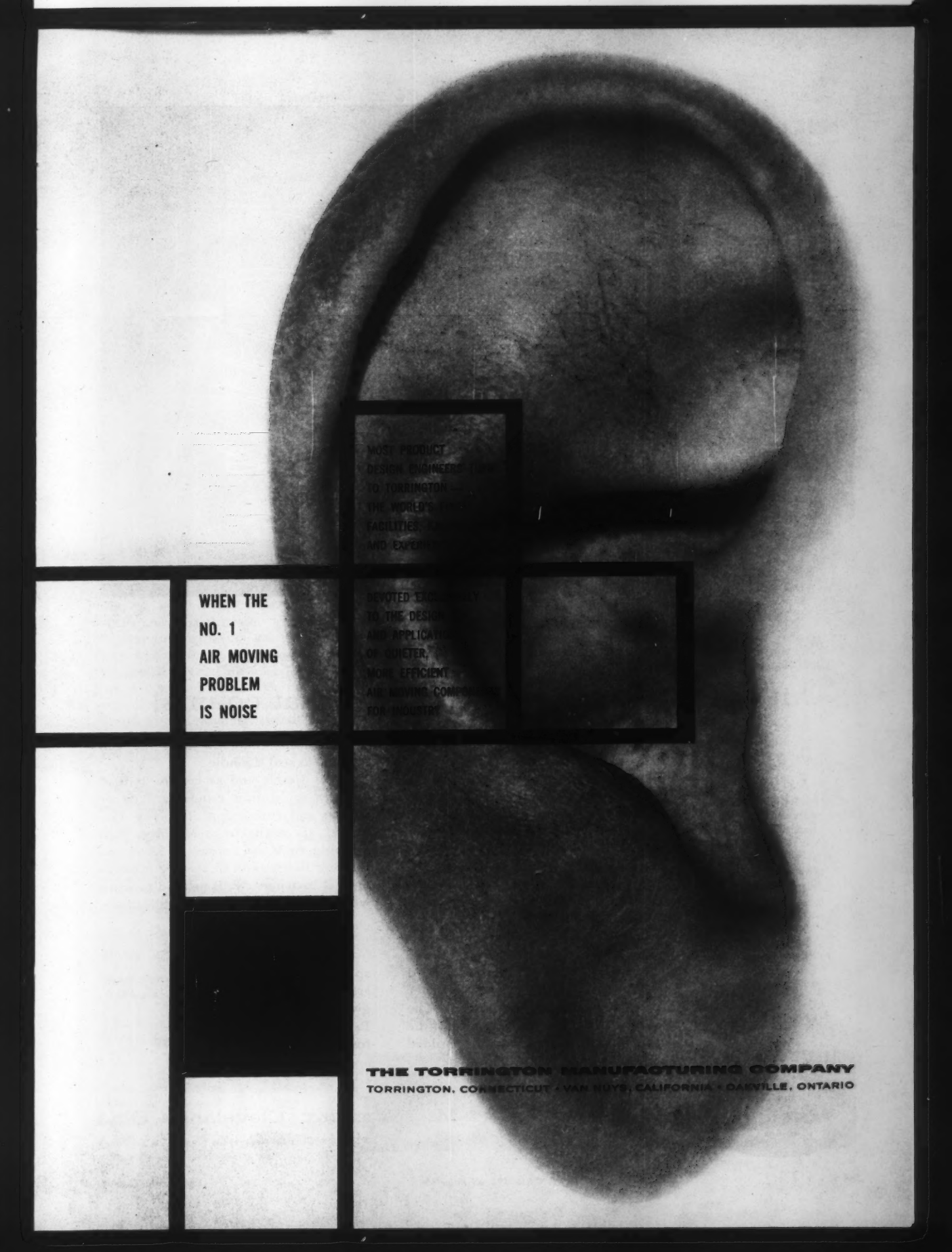
Configuration and properties of a multiple-channel coherent optical signal-processing system. Much of the versatility of the system is a consequence of the fact that a coherent optical system is essentially a spectrum analyzer.

The use of optical techniques for processing of information has been proposed frequently. Both coherent and noncoherent optical systems have been built. These systems possess tremendous potential as data processors because of: 1. Large storage capacity of photographic materials. 2. Two-dimensional nature of the storage medium. 3. Ease with which wide bandwidth signals can be recorded and made static on photographic materials.

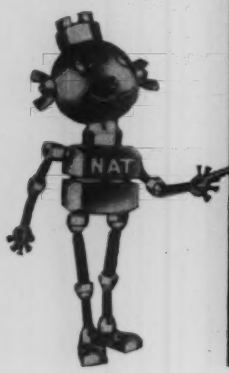
The advances in optical computing techniques, which form the major content of this paper, are the result of: 1. Use of coherent optical techniques. 2. Modification of the optical computer to have a multiple-

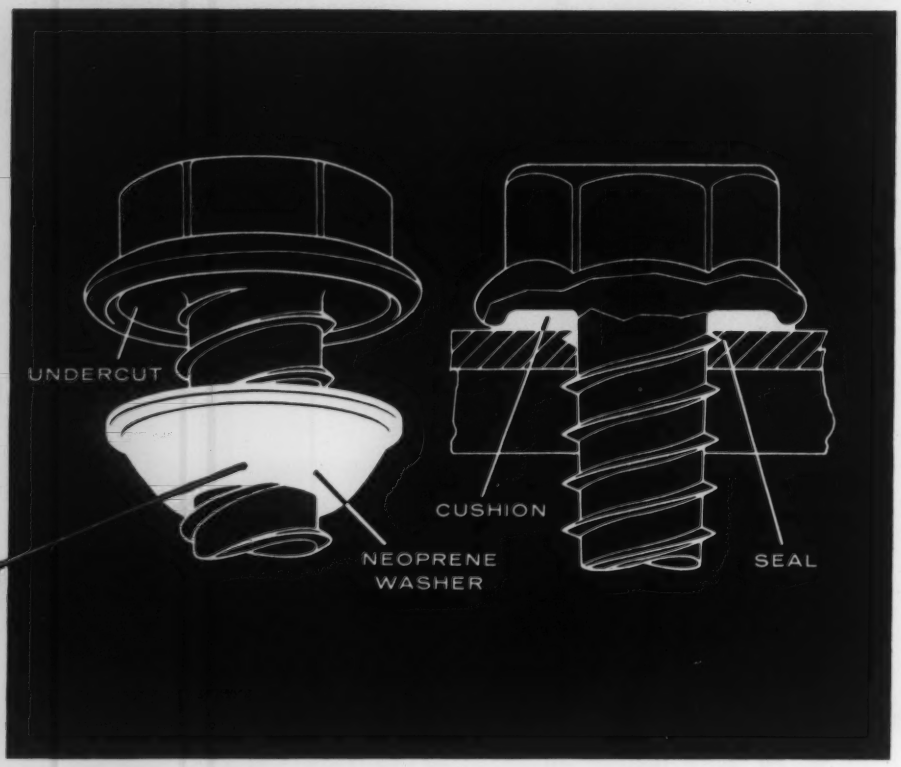
Circle 489 on Page 19

Circle 490 on Page 19→


WHEN THE
NO. 1
AIR MOVING
PROBLEM
IS NOISE
THE TORRINGTON MANUFACTURING COMPANY
TORRINGTON, CONNECTICUT • VAN NUYS, CALIFORNIA • DANVILLE, ONTARIO

NAT'S quick facts about Fasteners...





With TUFF-TITE® Fasteners ...it's the cushion control that counts!

TRADEMARK

You can be very sure of this, in using Tuff-Tite® Cushioned Fasteners.

The preassembled neoprene washer won't ooze off in just any old direction when it's compressed under the head.

It will stay put and do what it's intended to do:

- Form a firm, even cushion under the head • Seal off the fastener hole
- Prevent fluid leaking past the thread
- Dampen vibration noises around the head • Protect fine finishes against marring and crazing

. . . because Tuff-Tite's undercut head and tough molded neoprene washer assure consistent cushion control. The undercut confines the spread as the washer is compressed, and the molded shape guides the flow into the top threads, to seal the hole.

It's as simple and as certain as that, for any application requiring fastener sealing and cushioning. Tuff-Tite Fasteners* are available as Machine, Self-Tapping, or Wood Screws. as Stove and Roofing Bolts, and can also be made as Special Fasteners. We'll be glad to work with you on your possible applications.

*More details and specifications on standard types and sizes are given in the Tuff-Tite Fastener folder. Write for your copy.

National PRODUCTS

The National Screw & Mfg. Company • Cleveland 4, Ohio

California Division, The National Screw & Mfg. Company • 3423 South Garfield Avenue, Los Angeles 22, California

channel capability.

IRE paper, "Coherent Optical Data Processing," presented at Western Electronic Show and Convention, San Francisco, Aug. 18-21, 1959, 13 *pages.*

processes

Summary of Developments In Explosive Forming

Arthur Wickesser, Grumman Aircraft

Distinctive features and current applications of explosive forming. An obvious advantage is that the energy available for forming is almost unlimited. Also, the size of parts which can be shaped is limited only by the availability of sufficiently large blanks of material. No mechanical presses are required. The pressures which can be produced by far exceed those which could be generated by any conceivable mechanical forming press.

A critical matter in the use of explosive forming is the effect of strain rate on metal formability. Discussion in this paper covers uniaxial strain and biaxial strain.

Separate treatments are given to thin-wall circular members and thick-wall circular members. Operations discussed include: Forming of stiffening beads in flat sheet, deep drawing, cold welding, metal compacting, hot forming, blanking, shearing, and dimpling.

ASTE Paper No. 229, *"Recent Developments in Explosive Forming at Grumman Aircraft," presented at the ASTE Semi-Annual Meeting, St. Louis, Oct.* 8-10, 1959, 14 *pages.*

TO OBTAIN COPIES of papers or articles abstracted here, write directly to the following organizations:

Armour Research Foundation, Illinois Institute of Technology, 10 W. 53rd St,, Chicago 16, Ill.

GM Engineering Journal, Public Relations Staff, GM Technical Center, P. O. Box 177, North End Station, Detroit 2, Mich.

ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.

ASTE—American Society of Tool Engineers, 10700 Puritan Ave., Detroit 38, Mich.

IRE—The Institute of Radio Engineers, 1 East 79th St., New York 21, N. Y.

Stearns MODEL GS CLUTCH

NEW HIGH TORQUES — SAME SMALL SIZES

Sets new standards of reliability and maintenance convenience

Min. Diameter 4½ in.
Max. Diameter 9¼ in.
Min. Depth - - 3½ in.
Max. Depth - - - 6 in.

NEW Torque Ranges —
Dry — 12 to 1260 lb ft; Wet (oil) — 16 to 1140 lb ft.
(former ratings from 9 to 540 lb ft.)

NEW Stearns Friction Discs —
provide long, trouble-free life — greater resistance to heat and pressure . . . seldom need adjustment for wear. Type "GS" friction discs can be replaced, or adjusted quickly and easily with just a screwdriver as your tool kit . . . for lowest-cost-per-year operation . . . specify Stearns!

✓ Check — Compare these additional $avings features:

- Stationary Magnet Body — simplifies installation. No thrust loads on shafts or machine elements. All clamping forces are self-contained.
- Plug-in Electrical Connections — No slip-rings, no brushes to install or maintain.
- Shipped Fully Assembled — you receive units from Stearns completely assembled, tested, ready for installation.
- Duplexed Bearings—conservatively loaded, sealed, prelubricated... assures longer, trouble-free life.
- Versatile Control — can be electrically energized by virtually any type switching device of adequate capacity.

Call your local Stearns Representative, or write direct for complete "GS" data.

Stearns ELECTRIC CORPORATION
120 NORTH BROADWAY
MILWAUKEE 2, WISCONSIN

Circle 492 on Page 19

Helpful Literature
for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Motor Starting Relays

Klixon 6409 Series motor starting relays are designed for single-phase alternating current appliances having starting circuit loads up to 25 amp. Their features, operation, and specifications are found in illustrated Bulletin STRE-4. 4 pages. Texas Instruments Inc., Metals & Controls Div., Attleboro, Mass. B

Circle 601 on Page 19

Custom-Shaped Bars

How custom shaped hot rolled bars offer freedom in section design, reduce production costs, improve design, and simplify assembly is told in illustrated folder, "Creative Designing and Good Engineering Too." Several examples are shown and specifications are given. 4 pages. H. K. Porter Co., Conners Steel Div., Box 2562, Birmingham, Ala. A

Circle 602 on Page 19

Free-Piston Pump

An air-operated pump that handles anything that flows from molten metal to ice cream is subject of illustrated folder. The free-piston pump continues to operate while partly disassembled for cleaning or maintenance. Specifications are given. 4 pages. Crossley Machine Co., 308 Monmouth St., Trenton 9, N. J. E

Circle 603 on Page 19

Plastic Moldings

Compression, transfer, and injection molding processes for producing plastic moldings are discussed, and materials and sizes of parts available by each process are listed in Booklet MP-591. Properties of nine CDF molding materials are given. Some 35 typical parts made to order are described. 12 pages. Continental-Diamond Fibre Corp., Newark, Del. C

Circle 604 on Page 19

Glass Fabrics

Properties, construction, applications, and performance data on Uniglass fabrics for the reinforcement use in electrical, boating, tooling, and other industrial applications are contained in reference handbook. Various glass fabric weaves are covered, as are finishes, quality control, and specifications. 32 pages. United Merchants & Manufacturers Inc., 1412 Broadway, New York 18, N. Y. D

Circle 605 on Page 19

Leather Packings

Much basic data on mechanical leather packings are found in the pages of this profusely illustrated handbook, a joint effort of the leather packing manufacturers. This revised edition contains information on leather flange packing, U packing, washers, cup packing, and V packing. Pressures encountered, types of mediums to be sealed, temperature ranges, and much other data are covered. 56 pages. Excelsior Leather Washer Mfg. Co., 720 Chestnut St., Rockford, Ill. K

Circle 606 on Page 19

Tube Fittings

Aid in selecting the proper tube fittings for various service and installation requirements is offered by the tube fittings finder, Bulletin 4306-B1. Shape charts for six types of industrial fittings, plus tube working tools, are included. 4 pages. Parker-Hannifin Corp., Parker Fittings & Hose Div., 17325 Euclid Ave., Cleveland 12, Ohio. F

Circle 607 on Page 19

Pressure Reducing Valves

Single seat, tight closure, self-contained Type B pressure reducing valves are described in Catalog Section 1. Piston operated and actuated by internal pilots, they can be used for steam, oil, air, gas, or water. Five body types have ranges up to 900 psi at 750° F. 4 pages. Atlas Valve Co., 280 South St., Newark 5, N. J. D

Circle 608 on Page 19

High Strength Steel

Possessing high strength up to 1000° F, Potomac A high strength steel is offered for aircraft, missile, and rocket use. The Type H-11 chromium-molybdenum-vanadium hot work steel is described in Booklet TS-38. Properties and applications are given. 24 pages. Allegheny Ludlum Steel Corp., Oliver Bldg., Pittsburgh 22, Pa. F

Circle 609 on Page 19

Carbon Steel Bars

Revised Buyer's Guide 12-5 gives information on additional types of leaded steel bars, including Ledloy 375. Stock sizes and shapes of over 20 different kinds of cold finished carbon steel bars are shown, along with comparative data on strength, workability, machinability, and heat treatment. 4 pages. Joseph T. Ryerson & Son, Inc., Box 8000-A, Chicago 80, Ill. I

Circle 610 on Page 19

Fluid Power Generators

Hele-Shaw variable displacement and Hydramite constant displacement high pressure pumps are the fluid power generators described and illustrated in Catalog P58. Engineering data, design and construction features, and specifications are included. Maximum continuous pressures range up to 2500 psi. 20 pages. American Engineering Co, Philadelphia 37, Pa. E

Circle 611 on Page 19

Hydraulic Fittings

Extensive line of fluid power accessories for industrial hydraulic piping systems is described and illustrated in Catalog 60. Covered are JIC flared tube fittings, pipe fittings, hose fittings, valves, and miscellaneous items. Many standard and special fittings are included. 64 pages. L & L Mfg. Co., 21590 Hoover Rd., Warren, Mich. H

Circle 612 on Page 19

Thyratron Controls

Fast response, precise power control, and high efficiency are features of magnetic thyratron controls, operational and application, data for which are provided in Bulletin MTC 558. Rise time is less than 500 microseconds and pulse amplitude is up to 140 v. 5 pages. Fairfield Engineering Corp., 934 Hope St., Springdale, Conn. B

Circle 613 on Page 19

Air-Hydraulic Boosters

Miller air-hydraulic boosters which convert shop air into intensified (up to 10,000 psi and over) hydraulic pressures for operating cylinders and other hydraulic devices are discussed in Engineering Bulletin B-200P. Mounting and dimensional data and prices are given, along with much field application information. 24 pages. Flick-Reedy Corp., Miller Fluid Power Div., York & Thorndale Roads, Bensenville, Ill. J

Circle 614 on Page 19

Drafting Equipment

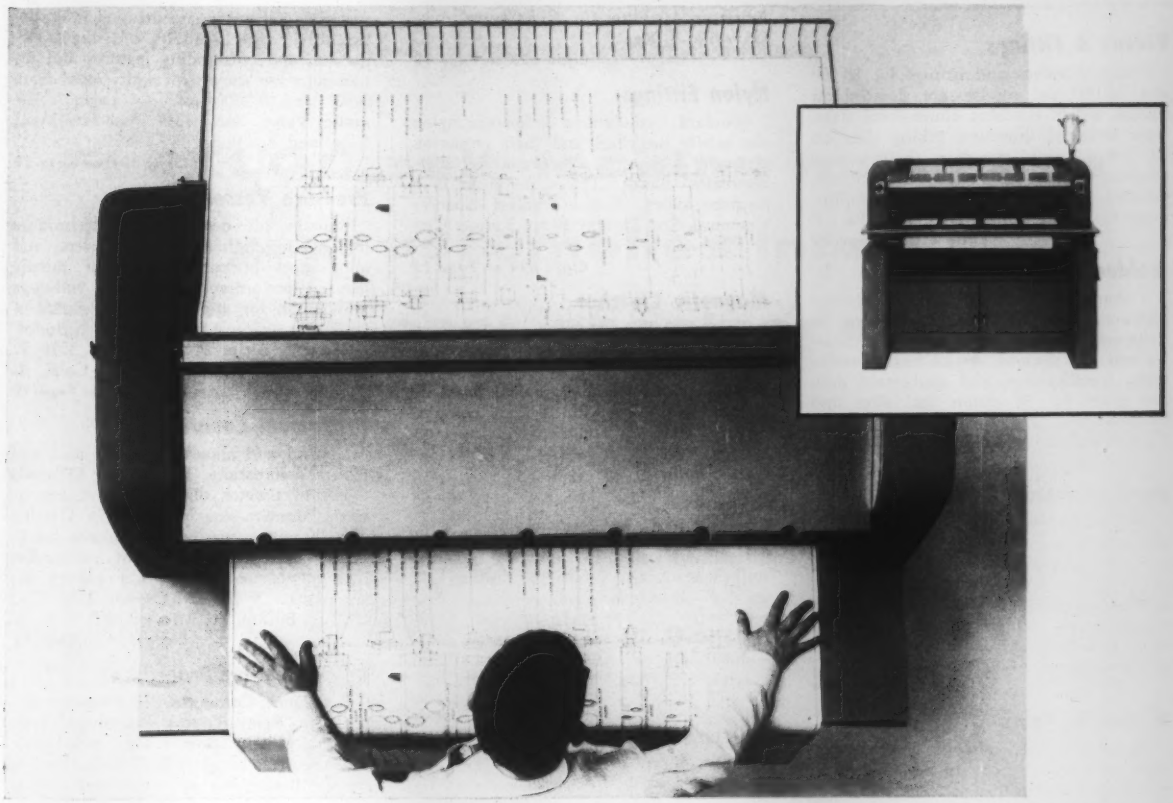
"Functional Drafting" Supplement No. 2 covers such subjects as the modern aircraft industry drafting room, the drafting table and its use, drafting machines, allocation and layout of floor space, and cost reduction factors. Second part is devoted to the use of a drafting machine. 30 pages. Kuhlmann Straube Co., Box 358, Oakville, Ont. B

Circle 615 on Page 19

Cooling Tower Drives

Horsepower ratings, sizes, dimensions, and other technical data are presented for Type CU speed reducers, intended for cooling tower service, in Bulletin 135-S. Compact units handle heavy duty fans under extreme heat and humidity conditions. 8 pages. Cleveland Worm & Gear Co., 3300 E. 80th St., Cleveland 4, Ohio. F

Circle 616 on Page 19



Announcing . . .

Ozalid's new

STREAMLINER 200

Now you can have a whiteprinter with "big machine" features at a slim-budget price. And you can enjoy the convenience of on-the-spot printmaking round the clock. Make all the prints you need, inexpensively and without delay. With the new Streamliner 200 it's easy. There's no make-ready or cleanup . . . anyone can learn to use the 200 in minutes. Check these important features:

- Makes prints up to 42" wide by any length
- Front and rear print stacking
- Simple dry-developing system
- Easy turn-on, turn-off controls
- Smooth-running electronic drive with speeds up to 14 fpm
- Hook-on tracing receiving tray (optional at extra cost)

And the versatile Streamliner 200 handles the whole range of Ozalid sensitized materials . . . lets you turn out gum-backed labels, photographs, cloth maps, or color transparencies!

For complete details on the new Streamliner 200, mail coupon today!

OZALID

Division of General Aniline & Film Corporation
In Canada: Hughes-Owens Co., Ltd., Montreal

Ozalid, Dept. S-11-26, Johnson City, N.Y.

Please send me free descriptive brochure on the new Streamliner 200.

Name_____

Company_____

Position_____

Street_____

City_____ Zone_____

State_____

Valves & Fittings

Standard valves and fittings for 30,000 and 60,000 psi service are detailed in catalog which contains dimensional data, cross sectional drawings, tubing sizes on 32 items. Four types of thermocouple adapters and the HIP relief valve are also detailed. 16 pages. High Pressure Equipment Co., 1222 Linden Ave., Erie, Pa. F

Circle 617 on Page 19

Molded Packings

T-shaped form of Palmetto molded packings, the G-T ring, is detailed in Engineering Handbook GTR-759. Illustrations, descriptions, service recommendations, specifications, and application data are given for 88 piston seal sizes and 68 rod seal sizes. 8 pages. Greene, Tweed & Co., North Wales, Pa. E

Circle 618 on Page 19

Heat Resistant Castings

Up-to-date information on heat resistant cast alloys is furnished by set of tabbed data sheets bound in file folder. Each of 28 alloys is covered as to heat treatment, applications, design and fabrication considerations, with a summary of properties. 56 pages. Alloy Casting Institute, 286 Old Country Rd., Mineola, N. Y. D

Circle 619 on Page 19

Hydraulic Pump

Operating characteristics, installation, and performance of the AP6V Series pump, a variable displacement, two-stage hydraulic unit for aircraft use, are found in illustrated Booklet K114. Delivery is 16 gpm at 3750 rpm and 3000 psi. 4 pages. American Brake Shoe Co., 530 Fifth Ave., New York 36, N. Y. D

Circle 620 on Page 19

Hose & Tube Fittings

Easy-to-find listings of brass and steel tube fittings, tube working tools, hose, hose ends, and assemblies used in hydraulic and pneumatic systems are content of condensed Catalog C-301. Specifications are given. 16 pages. Weatherhead Co., Ft. Wayne Div., 128 W. Washington Blvd., Ft. Wayne, Ind. J

Circle 621 on Page 19

Process Control

Facilities brochure outlines company's engineering services and products for automatic measurement and control of processes by electronic and electro-mechanical techniques. Ground support and production test equipment for both missile and aircraft system, as well as industrial test equipment, are depicted. 16 pages. American Bosch Arma Corp., Chicago Div., 5857 W. 95th St., Oak Lawn, Ill. J

Circle 622 on Page 19

Heating Coils

Construction and operation of Kennard/Nelson heating coils are detailed in Bulletin HC-102. Dimensions, air friction charts, temperature rise charts for pressures from 2 to 30 psi steam, condensate rates, water velocity and pressure drop graphs, heat transfer factor graphs, and other data are presented. 32 pages. American Air Filter Co., 215 Central Ave., Louisville 8, Ky. G

Circle 623 on Page 19

Nylon Fittings

Standard formulations of Spencer nylon are briefly described and their properties given in a table in "Properties & Characteristics" folder. Prices are given in a separate folder. 6 and 4 pages. Spencer Chemical Co., Dwight Bldg., Kansas City 5, Mo. I

Circle 624 on Page 19

Magnetic Clutches

The new water-cooled Magneclutch magnetic particle clutch for tension control and cycling can also be used for braking. Sizes from 10 to 200 lb-ft are offered. Bulletin EPD 6126-3 contains complete information. 4 pages. Vickers Inc., Electric Products Div., 1815 Locust St., St. Louis 3, Mo. I

Circle 625 on Page 19

Electrical Contacts

Revised, condensed Catalog 601 describes materials, properties, forms, and uses of Gibson electrical contacts. Fine and coin silver, palladium, gold, platinum, silver alloy, and powdered metal contacts are covered. 4 pages. Gibson Electric Co., Box 614, Delmont, Pa. F

Circle 626 on Page 19

Thermostat Metals

Bulletin TRU-9 relates the benefits of heat treating of thermostat metal parts, the causes of stresses, and discusses design as influenced by heat treatment. 2 pages. Texas Instruments, Inc., Metals & Controls Div., Attleboro, Mass. B

Circle 627 on Page 19

Cold Heading Wire

Folder compares the cost, corrosion resistance, and cold heading characteristics of commonly used grades of stainless steel cold heading wire. 4 pages. Universal-Cyclops Steel Corp., Station Street, Bridgeville, Pa. F

Circle 628 on Page 19

Solenoid Valves

Solenoid valve stock list and selection Guide 506 contains engineering information, illustrations and flow diagrams of every type ASCO valve in stock. Line includes two, three, and four-way and manual reset types. 16 pages. Automatic Switch Co., Florham Park, N. J. D

Circle 629 on Page 19

Pipe Thread Fittings

Tru-Seal pipe thread fittings provide rapid positioning, freedom from leakage, and eliminate overtightening damage in assembling piping, valve, and pump installations. How common types of piping problems are solved by there fittings is discussed in illustrated bulletin. 4 pages. Flick-Reedy Corp., Tru-Seal Div., York & Thorndale Roads, Bensenville, Ill. J

Circle 630 on Page 19

Air, Water & Oil Cylinders

Line of air, water, and oil cylinders, and valve-cylinder combinations for automation applications are detailed in Bulletin 91017. Specifications, ordering information, and outstanding features and dimensions are shown for units rated from 0-300 and 0-2500 psi. 24 pages. Airmatic Valve, Inc., 7317 Associate Ave., Cleveland 9, Ohio. G

Circle 631 on Page 19

Pressure Vessels

Bulletin 141 describes new techniques for making titanium, stainless steel, and alloy steel pressure vessels for missile use. A performance chart and full-page nomograph for approximating weights of vessels in various materials are included. 12 pages. Airite Products, Inc., 3516 E. Olympic Blvd., Los Angeles 23, Calif. L

Circle 632 on Page 19

Instrument Counters

General and material specifications and model designations for Y and D series of Productimeter digital readout instrument counters are furnished in Catalog 400. Counters are used in missile tracking devices, radar equipment, navigation instruments, computers, and gaging instruments. 8 pages. Durant Mfg. Co., 1929 N. Buffum St., Milwaukee 1, Wis. K

Circle 633 on Page 19

Relay Testing Procedures

Technical Committee II Progress Report on "Relay Testing Procedures" covers dry circuits (low energy switching), measurement of electrical characteristics, contact life testing, environmental testing, vibration testing, and shock and acceleration testing. 70 pages. National Association of Relay Manufacturers, Box 6, Stillwater, Okla. P

Circle 634 on Page 19

Cast Meehanite Shapes

How Meehanite bars, bushings, and shapes, cast in standard shapes to exact physical properties, are used for cams, pistons, gears, plates, box and flat parallels, and other components is shown in illustrated Bulletin 45. 16 pages. Request on company letterhead from Meehanite Metal Corp., 714 North Ave., New Rochelle, N. Y. D

Shock & Noise Control

"Engineering for Control of Dynamic Environments" is title of illustrated brochure covering advancements in the field of shock, vibration, and noise analysis and control. Company experience, facilities, and instrumentation used in research and development, design engineering, and production are detailed. 8 pages. Request on company letterhead from Barry Controls, Inc., 700 Pleasant St., Watertown 72, Mass. B

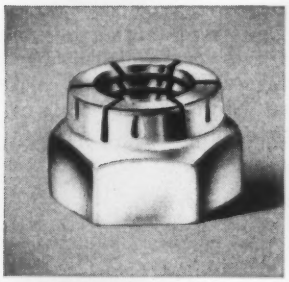
Hydraulic Equipment

Dynex line of hydraulic pumps, valves, cylinders, motors, hand pumps, and power units is subject of spiral-bound, illustrated Bulletin DG-3. Various types of each product are detailed, specifications are presented, and many applications are shown. Request on company letterhead from Dynex Inc., 777 Dynex Dr., Pewaukee, Wis. J

SPS RELIABILITY / *A dynamic standard of predictable performance*

FLEXLOC self-locking nuts keep your assemblies intact, despite impact, shock or vibration

Stroboscopic photo shows action of transfer mechanism on a cold-forging machine operating at approximately 16 cycles a minute. The numerous FLEXLOC locknuts used to fasten this assembly stay put despite constant shock and vibration, eliminate the nuisance of frequent retightening.



FLEXLOC self-locking nuts help solve the problem of keeping threaded fasteners tight. Repeated shock, high-speed oscillation, heavy pounding will not shake them loose. They help give your products greater reliability, a qualification that is no longer just a talking point, but a major competitive advantage.

FLEXLOCs are 1-piece, self-locking fasteners requiring no lockwashers, jam nuts, cotter pins or wiring. There is nothing extra to put together, come apart or get lost . . . and no nonmetallic inserts to deteriorate, be chewed up by rough bolt threads, or weaken the structure of the nut. With a FLEXLOC, every thread, including those in the locking section, carries its full share of the tensile load.

A FLEXLOC goes on like an ordinary nut. Start it with your fingers; tighten it with a hand or speed wrench. As soon as 1½ threads are past the top, the FLEXLOC is fully locked. It serves as either a locknut or a stop nut.

Because they require no auxiliary locking devices, FLEXLOCs facilitate design and specification, simplify inventory and handling, reduce assembly time and costs. They also save on maintenance, because they are readily removed and can be reused repeatedly without impairing their locking reliability. See your authorized FLEXLOC distributor for complete information on sizes, materials and finishes. Or write SPS—manufacturer of precision threaded industrial fasteners and allied products in many metals, including titanium. Flexloc Locknut Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

SPS **Jenkintown • Pennsylvania**

Standard Pressed Steel Co. • The Cleveland Cap Screw Co. • Columbia Steel Equipment Co. • National Machine Products Co. • Nutt-Shel Co. • SPS Western • Standco Canada, Ltd. • Unbrako Socket Screw Co., Ltd.

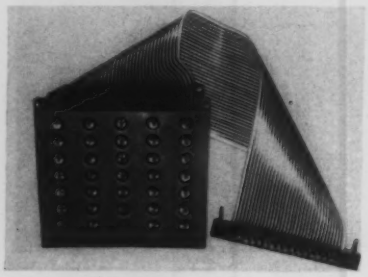
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Printed Circuits

flexible units are small and lightweight

Flexprint wiring is made by sandwiching thin copper conductors between insulating layers of flexible plastic sheeting. Flexible circuits simplify design of electronic and electrical systems, since they can be routed easily through crowded layouts. Applications include use in complex circuits such as computers, telephone and telegraph switchboards, relays, and industrial controls. Inertness of circuits makes them suitable for service under corrosive conditions, and small size, and light weight permits use in aircraft and missiles. **Sanders Associates Inc.**, 137 Canal St., Nashua, N. H. B

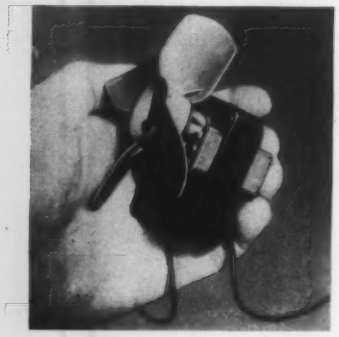


Circle 635 on Page 19

Fractional-Horsepower Motor

has lubrication sealed in turning rotor

Unit-bearing, low-cost, fractional-horsepower electric motor, called the S/L-1085, has a wide range of industrial and domestic uses. Lubricating oil is factory-sealed inside turning rotor, cutting down oil oxidation to a minimum and eliminating future oiling. Motor can be wound for 110 or 220 v, 50/60-cycle operation. Rotor turns on a stationary shaft at 3400 rpm without load, and 2600 to 3200 rpm with recommended load. Horsepower ratings range from 1/750 to 1/185 hp. Unit operates in a wide range of temperatures from −10 to +250 F. It is available as a skeleton motor or in a housing with various mounting plates. Unit can be fitted with 2 to 3-in. diam circulating blowers, or 4 to 6-in. plastic fans (shown), or with gear boxes. **Howard Industries Inc.**, Dept. 26, 1760 State St., Racine, Wis. K

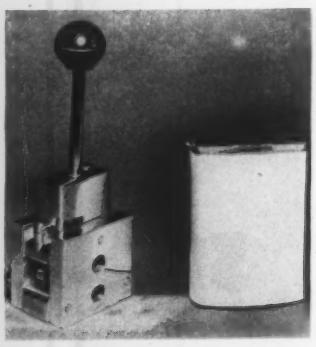


Circle 636 on Page 19

Miniature Valve

can be used interchangeably

Full-flow valve is a miniature unit capable of performing same work as current valves five times its size and weight. In addition to weight and size saving, valve can be used interchangeably as pneumatic, hydraulic, or vacuum-type unit. Applications include use in machine tool, automotive, aircraft, missile, surgical, home appliance, and marine industries. **Gabriel Co.**, 1148 Euclid Ave., Cleveland 15, Ohio. F

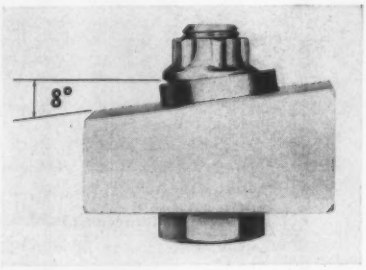


Circle 637 on Page 19

Nut-Washer Combination

accommodates surfaces with up to 8 deg slope

Kaylock self-aligning, six-point, nut-washer combination is designed for 160,000 psi short-thread bolts. It accommodates surfaces with up to 8 deg slope, eliminating spot facing. Compactness permits use of wrenches two sizes smaller than those used on standard AN and NAS nuts. Nut is 48 to 62 per cent lighter than previous self-aligning hex nuts, depending on thread size. **Kaynar Mfg. Co. Inc.**, Box 2001, Terminal Annex, Los Angeles 54, Calif. L



Circle 638 on Page 19

Identification Plates

in many metals, sizes, and finishes

Line of 0.02-in. thick identification plates can be supplied for either pin or press-on mounting. Plates are available in a full range of colors, sizes, shapes, and metals. They are suitable for use as panels and dial facings. Enameled, etched,

Creative hydraulics by Sundstrand

Improve Your Mobile Equipment With These Transmission Characteristics

Custom-Designed Hydrostatic Transmissions

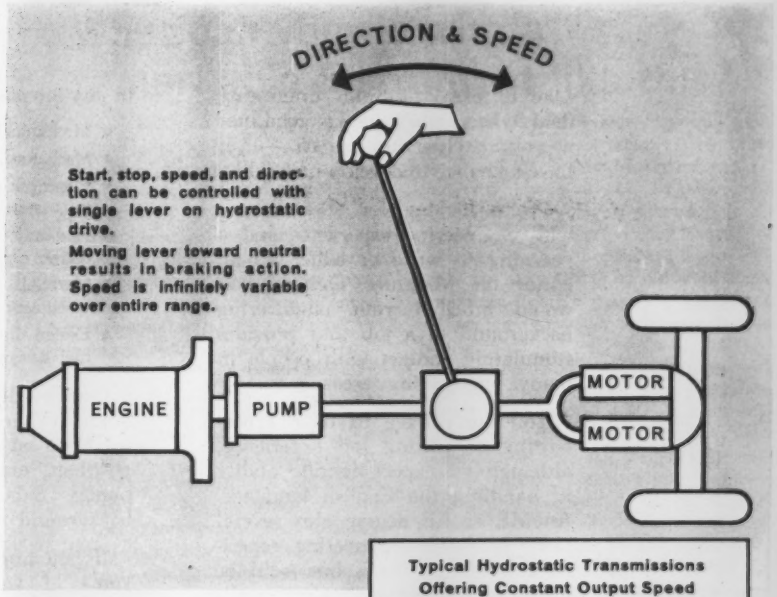
- **Single-Lever Direction and Speed Control**
- **Infinitely Variable Speed Control**
- **Automatic Torque Multiplication**
- **Variable Input, Constant Speed Output**
- **Nonslip Differential**

Hydrostatic drives simplify control of vehicle propulsion and auxiliary functions—provide other operating characteristics unattainable with ordinary power transmission or drive methods—all at sharply reduced maintenance levels.

The basic components of Sundstrand hydrostatic transmissions are axial piston pumps and motors of either variable or fixed displacement. Used in various combinations with Sundstrand valves and controls, they are custom-combined to give your equipment the precise operating characteristics you need for optimum performance and competitive sales advantage.

Typical applications for Sundstrand hydrostatic transmissions include: Alternator drives on construction and firefighting equipment, refrigeration compressor drives, fan drives in air conditioned buses, conveyor drives on agricultural, construction and mining equipment, and propulsion for many types of mobile equipment.

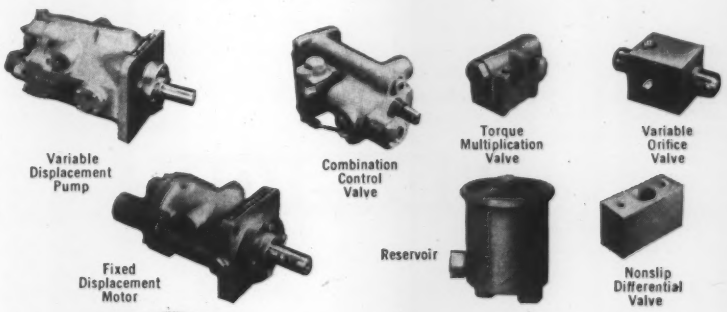
For complete details, send a brief outline of your requirements to the address below:


DIRECTION & SPEED
Start, stop, speed, and direction can be controlled with single lever on hydrostatic drive.
Moving lever toward neutral results in braking action. Speed is infinitely variable over entire range.
ENGINE
PUMP
MOTOR
MOTOR

Typical Hydrostatic Transmissions Offering Constant Output Speed

Output HP	Pump Input-Speed Range—RPM	Motor Constant Output Speed RPM ±5%*
2 hp	300 to 3000	1200
3 hp	450 to 3000	1800
4 hp	600 to 2500	2400
6 hp	800 to 2400	3000
8 hp	850 to 2300	3300
9 hp	950 to 2200	3600

*Under normal rated load conditions, motor output speed can be held constant within ± 5%.



SUNDSTRAND

SUNDSTRAND HYDRAULICS

DIVISION OF SUNDSTRAND CORPORATION

2210 Harrison Ave., Rockford, Ill.—Eastern Sales Office: 89 Summit Ave., Summit, N. J.

Wanted: Engineers

with an interest in writing

Like to break into an interesting field where you'll make good use of your engineering talents — yet have a chance to develop new skills?

We're looking for several men with engineering experience and a yearning to write or edit. As an editor on MACHINE DESIGN, you would broaden your engineering background in a job that provides stimulating contact with people in many engineering areas.

You don't have to have actual writing or editing job experience, although we expect definite ability in handling the English language. An ME or EE degree plus several years of design-engineering experience would be ideal, but we'll be happy to consider equivalent qualifications. Age: 25 to 35.

If you've worked in a design-engineering specialty area, we'd like to hear about it. We're interested in any job experience or training in:

- Mechanical drives, controls, systems
- Mechanical components, assemblies
- Electrical or electronic drives, controls, systems
- Hydraulic or pneumatic systems, drives, controls
- Materials and finishes selection or specification
- Design for manufacture or production design

Our headquarters are in Cleveland. There is opportunity for travel to engineering meetings, expositions, and manufacturing companies. Salary will depend on your background and experience.

If you are interested, send a resume of your engineering background, and any evidence you may have of writing ability (we'll return this if you wish) to: Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

MACHINE DESIGN

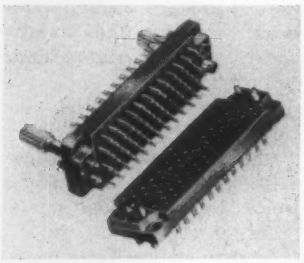
lithographed, or anodized finishing insures resistance against scratches and weather damage. **Dickey-Grabler Co.**, 10302 Madison Ave., Cleveland 2, Ohio.

Circle 639 on Page 19

Electrical Connectors

subminiature units have 29 and 75 contacts

Two subminiature electrical connectors are for aircraft and instrumentation applications requiring extreme miniaturization. The 29 and 75 -contact units are available with reversed guides or polarizing screwlocks. Electrical and mechanical ratings meet or exceed applicable paragraphs of MIL-C-5015 and MIL-C-



8384. Breakdown at sea level is 1900 v rms, and current rating is 5 amp. Contacts are phosphor bronze, gold plate over silver plate for low contact resistance and ease of soldering. Floating contacts insure positive self-alignment of each contact. Body material is molded from glass-filled diallyl phthalate. **Electronic Sale Div., DeJur-Amsco Corp.**, 45-01 Northern Blvd., Long Island City 1, N. Y. D

Circle 640 on Page 19

Miniature Slip Clutch

adjustable unit has concentricity to 0.0003 in.

Adjustable slip clutch, designated Apollo, is available for use in precision gear trains, computers, servo mechanisms, breadboard setups, recorders, and other devices requiring precision overload protection. It has wide torque range of 0 to 100 oz-in., and repeatable breakaway torque. Made of corrosion-resistant materials, clutch is 0.45 in. long by 0.63 in. in diam, and weighs 0.03 lb. It has no backlash, chatter, or galling. Concentricity is 0.0003 in.

What can you do with a remarkable instrument like this?

We knew we had an outstanding instrument in our product line when this readout device was introduced several years ago. It proved to be ahead of its time during those early days, but now this remarkable precision instrument for displaying data is gaining acceptance in many industries. It's about as big as a candy bar, and it will display, store, or transfer up to 64 different numbers, letters, or symbols without using complicated conversion equipment and "black boxes."

This is an entirely new species of readout device so we had to give it a new name, the Readall* readout instrument.

We developed the Readall instrument for data display in flight control equipment. We knew the Readall instrument was fine but didn't know just *how* valuable it was. But one of our engineers did. He designed a complete new pipeline control system based on the new instrument. The application was a breakthrough in data handling, and the control system is a big success.

Naturally, we put the Readall instrument on the market so systems engineers could use it to improve their control systems. We announced the Readall instrument as ". . . an electro-mechanical, D.C. operated, readout device for displaying characters in accordance with a pre-determined binary code . . . a compact, self-contained device . . . which can be applied to the output of digital computers, teletype receiving equipment, telemetering systems, or wherever data must be displayed."

Other systems have been developed with separate units for data display, decoding, storing, and electrical readout. These separate units cost more and occupy more room. Market response confirms the need for *one*, *small*, inexpensive unit that does all three jobs. The Readall instrument serves the purpose.

We'd like to discuss possible applications for the Readall instrument with you. If you want information as to possible applications you have in mind for this remarkable instrument, please fill in the coupon.

*Trademark

"Pioneers in Push-Button Science"

UNION SWITCH & SIGNAL
DIVISION OF WESTINGHOUSE AIR BRAKE COMPANY
PITTSBURGH 18, PENNSYLVANIA

Union Switch & Signal
Division of Westinghouse Air Brake Company
Pittsburgh 18, Pennsylvania

Here is a possible application we have in mind for the Readall instrument:

_____

_____

☐ Send more information about the Readall instrument

Name _____ Title _____

Company _____

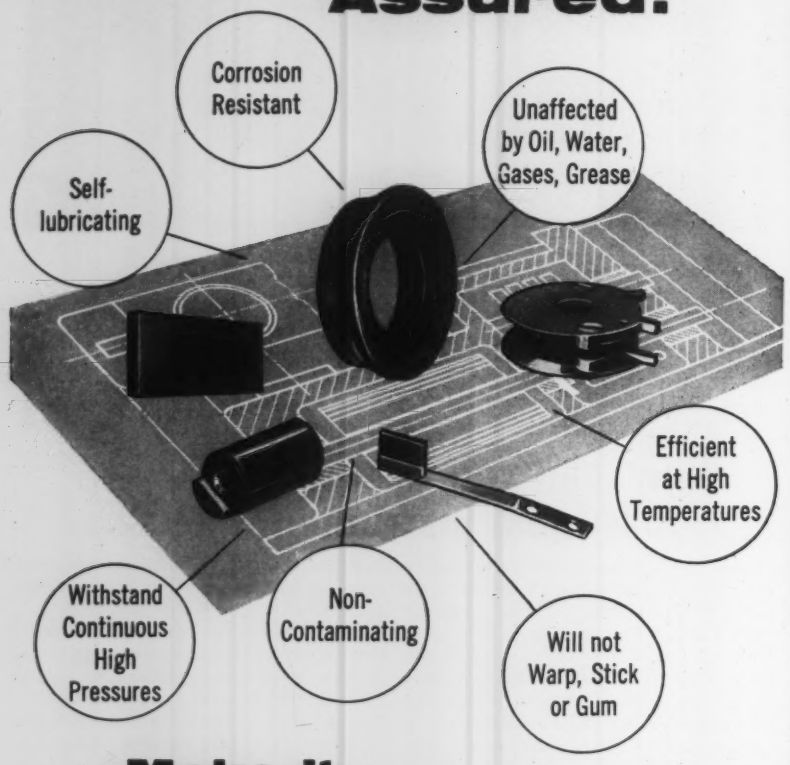
Address _____

City _____ Zone _____ State _____

See us at Eastern Joint Computer Conf. Dec. 1, 2, 3, 1959
Statler Hilton Hotel, Boston, Mass. Booths #1 and #2.

Circle 497 on Page 19

DESIGN FLEXIBILITY Assured!



Make It–

MORGANITE

THE "THOUSAND APPLICATION" MATERIAL

First Choice of the Designer/Engineer for:

- **Bearings**
- **Gland Rings**
- **Electrical Contacts**
- **Pump Vanes**
- **Seal Noses**
- **Piston Rings**
- **Valves**
- **Slides**
- **Rod Packings**
- **Special-purpose Commercial and Military Components**

Morganite has the answer to countless hard-to-solve design considerations. Its many inherent electro-mechanical advantages afford engineers extremely wide latitude and a high degree of flexibility. For example, self-lubricating Morganite bearings are ideal for incorporation in sealed mechanisms. Radar contacts of Morganite are employed in critical military and commercial systems because of exceptional dependability over a wide range of temperatures. For suggestions on your design problems, just call or write, Morganite!

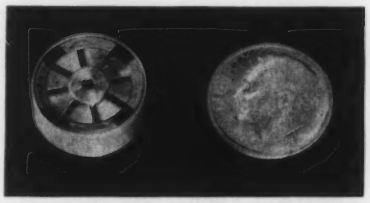
Morganite

INCORPORATED ... FOR OVER HALF A CENTURY

3314 48th Avenue, Long Island City 1, New York

In Canada: Morganite Canada Ltd., Toronto

Manufacturers of Fine Carbon Graphite Products including Mechanical Carbons, Motor/Generator Brushes, Carbon Piles, Current Collectors and Electrical Contacts ... Distributors of 99.7% Pure Al_2O_3 Tubes and Crucibles



Unit can be supplied with integral gear blank. Gear is made to order. **Northern Union Inc.**, 1020 Holly Ave., Arcadia, Calif. L

Circle 641 on Page 19

One-Package Coating

for polyesters and phenolic plastics

Available in a wide selection of colors and wide gloss range, Uni-Clad one-package coating possesses unusual bonding and weathering characteristics. It shows excellent resistance to flexing, impact, abrasion, moisture, acids, and alkalies. Coating is for glass-fiber-reinforced polyester and phenolic plastics. It can be applied by either spray or dip-tank in a one-coat operation, or used as top coating in a two-coat system where primer is required to fill glass-fiber pattern. Two new one-package primers have also been developed, one a water-base primer and the other a solvent type. **Universal Paint & Varnish Inc.**, Bedford, Ohio. F

Circle 642 on Page 19

Solenoid Valves

small units have many applications

Small, compact solenoid valves are available in sizes, types, patterns, orifice openings, and voltages for a wide range of applications. Mastermite valves are for use on a variety of media including air, water, petroleum products, coolant, oxygen, hydrogen, and acetylene. They are made in sizes $\frac{1}{8}$ and $\frac{1}{4}$ in. NPT, in both conduit and grommet types. Four patterns of each size and type—globe, bottom outlet, angle left, and angle right—are furnished. Ten orifice sizes range from 3/64 to $\frac{1}{4}$ in. Valves can be used on pressures from vacuum to 540 psi. They are standard with 115 v ac coils, but are also available in 12, 24, 208, and 460 v ac coils. Features in-

Another Tinnerman Savings Story...

Easier, faster, better, cheaper...4 reasons to use **SPEED GRIP®** Nut Retainers

Easier ... because anyone anywhere on the J. I. Case tractor production line can snap the spring steel retaining legs of the SPEED GRIP into punched panel holes. No special skill required. Hole alignment is no problem – the nut "floats" inside the cage to compensate for normal tolerances in the parts being assembled.

Faster ... no staking, no welding. No retapping of paint-clogged threads because SPEED GRIPS can be applied *after* painting. And they pop quickly and easily into position for final assembly.

Better ... heavy-duty SPEED GRIPS make possible sturdy, reliable attachments because both the cage and the nut are made of high quality steel. In case of accidental cross-threading, the SPEED GRIP can easily be replaced. You never have to "make do" with a sub-strength fastening.

Cheaper ... J. I. Case estimates a savings of about 30% per fastener over the previous method.

Want to achieve these benefits of SPEED NUT Brand Fasteners for your product? Refer to your Sweet's Product Design File, section 7-Ti, then call your Tinnerman representative (listed in most Yellow Pages under "Fasteners"). Or write to:

TINNERMAN PRODUCTS, INC.
Dept. 12 • P. O. Box 6688 • Cleveland 1, Ohio

TINNERMAN
Speed Nuts®

FASTEST THING IN FASTENINGS®

CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales. FRANCE: Simmonds S. A., 3 rue Salomon de Rothschild, Suresnes (Seine). GERMANY: Hocano-Bundy GmbH, Heidelberg.

Whenever temperature and performance must go hand in hand SELECT AN RMC THERMOMETER

Available in all scale ranges from −150 F to +1000 F; in dial sizes from 1" to 5"; stem lengths from 2½" to 72" . . . with complete adaptability to any installation

Wherever exact knowledge of temperature is an important part of function, you will discover that there are a lot of good reasons for selecting RMC thermometers.

Suppose for instance that you are designing equipment for low temperature work. You know that an RMC thermometer is hermetically *dry-air* sealed so that no ice coating can ever form on the bimetallic element to stop readings at below freezing temperatures. You can *always* be sure of your low temperature readings.

If severe vibration is a factor, the extra damping of RMC thermometers goes to work to make reading easier, more accurate and to prevent fatigue of the registering element. And when necessary, it can always be easily re-calibrated without opening it or destroying its essential accuracy.

No moisture to freeze the element or fog the dial. RMC thermometers are hermetically *dry-air* sealed then immersion tested for 15 minutes.

No "over" or "under" readings. Re-calibration for extreme accuracy in any range, or necessitated by severe shock, can be done in seconds without breaking seal.

Permanent accuracy with freedom from vibration-caused variable is built in. Silicone damping and special damping bearing minimize vibration and keep shaft alignment true.

Write, wire or phone for catalog and detailed general specifications. If yours is a special application, tell us your requirements. RMC engineers will work with you in solving it.

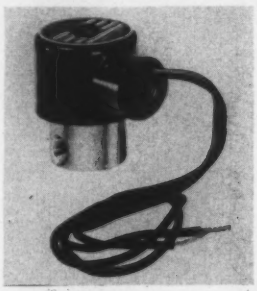
RMC

ROCHESTER MANUFACTURING CO., INC.
229 ROCKWOOD STREET • ROCHESTER 10, N.Y.

LIQUID LEVEL, TEMPERATURE and PRESSURE INSTRUMENTS

REPRESENTATIVES IN ALL PRINCIPAL CITIES

Circle 500 on Page 19



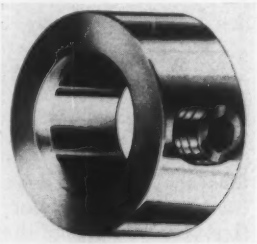
clude sturdy valve bodies, moisture-resistant coils constructed to avoid overheating, and positive leaktight, quiet seating. All parts in contact with media are stainless steel. **Marsh Instrument Co.**, 3501 Howard St., Skokie, Ill. J

Circle 643 on Page 19

Shaft Collars

of cold-drawn stainless steel

Noncorroding precision shaft collars are designed for service with chemical, electronic, food, beverage, and textile applications. Cold-drawn, stainless-steel collars are precision bored with chamfers machined on inside and outside corners. Stainless-steel socket cup-



point set screws are used with collar. Thirty-one bore sizes are available from ⅛ to 2⅛ in. in 1/16-in. increments. **Climax Metal Products Co.**, 863 E. 140th St., Cleveland 10, Ohio. G

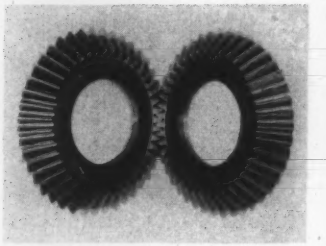
Circle 644 on Page 19

Spheroid Bevel Gears

with pitch diameters from 1 to 13½ in.

FMS multicontact, full-fillet bevel gears, with minimum of two teeth in contact at all times, provide for increased load capacity and smooth, quiet operation. Uniform tooth loading avoids concentrated stress,

minimizes backlash, and permits carrying of heavy loads at high speeds without scoring. Use of true involute form makes possible critical control of profile, spacing, and eccentricity, eliminating need for matching of gears or timing of teeth. Gears bearing the same parts number are interchangeable. Standard A series, for use in all ordinary industrial applications, is machined after heat treatment and affords a capacity similar to commercial standard for spiral bevel gears. Series AA, providing 50 per cent higher load capacity than Series A, is case hardened, with teeth silver



plated for positive lubrication during normal break-in period. Ratios available are 1:1, 2:1, 3:1, 3:2, and 4:3, with available pitch diameters from 1 to 13½ in. **Braun Gear Co.**, 239 Richmond St., Brooklyn 8, N. Y. D

Circle 645 on Page 19

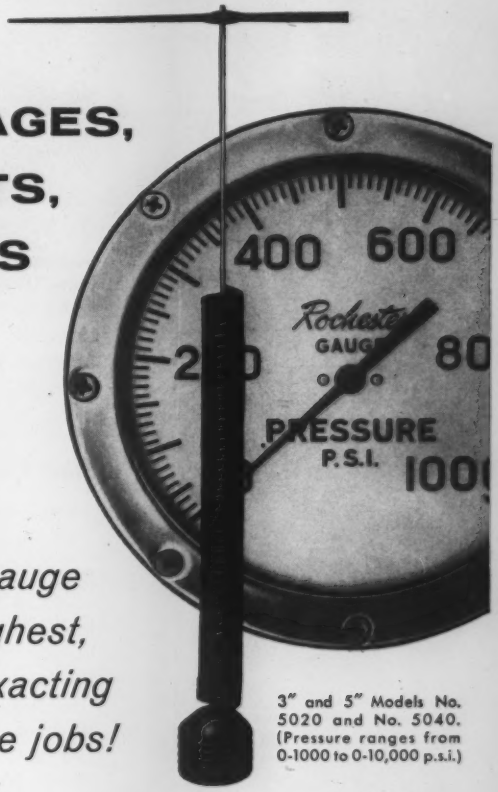
Snap-Action Switches

are nonsensitive to vibration and shock

Snapac small snap-action switches in pin plunger, lever action, and panel-mounting models feature positive make and break action, high contact pressure, and rugged construction. Each switch is nonsensitive to vibration and shock and has oversize silver contacts that provide stability against momentary high overload. High current capacity enables direct control of circuit. All switches have molded phenolic cases, brass switch blades, and ¼-in. type terminals with hole for solder connection. Model 750-150, a pin-plunger switch, is designed for limit, safety interlocking, and control-switch requirements. Models 750-250 and 750-251 are lever-action types and can be used on applications where low operating force is available. Panel mounting

Revolutionary New ROCHESTER HIGH PRESSURE GAUGE
has pointer connected directly to pressure element

NO LINKAGES,
NO PIVOTS,
NO GEARS
to wear,
waver
or lag



3" and 5" Models No. 5020 and No. 5040. (Pressure ranges from 0-1000 to 0-10,000 p.s.i.)

This is the gauge for your toughest, your most exacting high pressure jobs!

Now you can practically eliminate maintenance, replacement, and gauge failures—even under the most severe of high pressure service conditions. The new RMC Gauge, models 5020 and 5040, actually approaches the reliability and dependability of the fittings and valves used in pressure equipment.

It is the first pressure gauge to have the pointer directly connected to the pressure element, without linkage or pivots, and with no gears or hair springs.

The pressure element is a multiple turn bourdon coil, to which the pointer is permanently attached at one end. As pressure increases, the end of the coil rotates, moving the pointer with it.

The bourdon coil is made from small diameter tubing. Therefore, the pressure forces against the coil are reduced; the mechanical stress on the coil is less; and spring life, cycling life, overpressure, and endurance are all vastly higher than the conventional "C" type bourdon tube gauge.

For safety, long cycling life and continued accuracy under extreme conditions of overload pressures, high vibration, shock and line pulsation, the new RMC High Pressure Gauge is the one complete answer. Available in pressure ranges from 0-1000 to 0-10,000 p.s.i.; dial diameters 1½", 2", 3" and 5". (1½" and 2" models are eccentric pivot-drive types.)

Write, wire or phone for complete information.

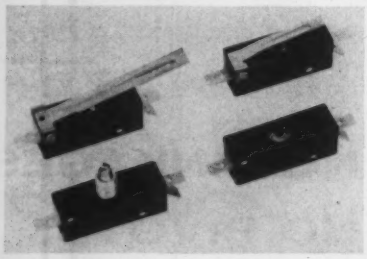
RMC

ROCHESTER MANUFACTURING CO., INC.
229 Rockwood Street, Rochester 10, N. Y.

LIQUID LEVEL, TEMPERATURE and PRESSURE INSTRUMENTS

REPRESENTATIVES IN ALL PRINCIPAL CITIES

Circle 501 on Page 19



is featured in Model 750-350. Switches are rated at 15 amp, 125 v ac; 10 amp, 250 v ac; ½ hp, 125/250 v ac. **Industrial & Commercial Controls Div., Controls Co. of America,** 9555 Soreng Ave., Schiller Park, Ill. K

Circle 646 on Page 19

Blind Rivets

are now available in copper

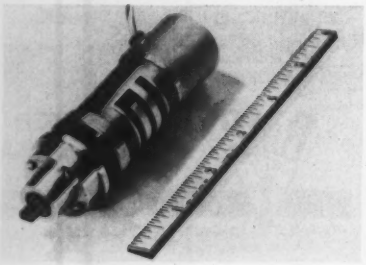
Pop rivets, made in aluminum, steel, and monel, are now also made with a steel mandrel plated with copper. Rivets are available in ⅛-in. diam size only, with grip range from 0.02 to 0.125 in. They can be used with pliers or pneumatic-type gun. **Pop Rivet Div., United Shoe Machinery Corp.,** Boston, Mass. B

Circle 647 on Page 19

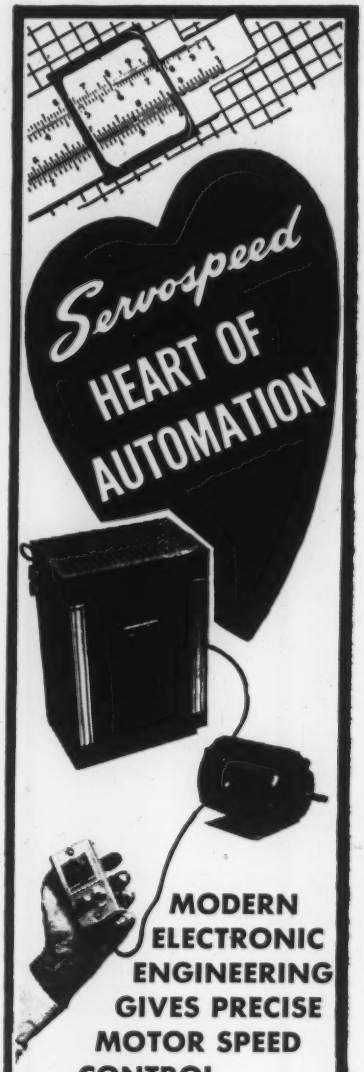
Miniature DC Motor

has continuous-duty ratings to 1/100 hp

Type GJ dc motor is 1⅜ in. in diam, has continuous-duty ratings to 1/100 hp, and can be wound for series, split-series, shunt, or universal operation. Unit meets MIL environmental specifications and, with filters, MIL radio noise specifications. Length of motor is determined by stack length chosen. Torques to 6 oz-in. can be obtained for intermittent duty. Motor can



Circle 502 on Page 19



MODERN ELECTRONIC ENGINEERING GIVES PRECISE MOTOR SPEED CONTROL

1/100 — 10 H. P.

Modern industrial electronic engineering has been coordinated with electric motor design to provide a versatile means for obtaining the full possible advantage of speed control in DC motors while operated from the regular alternating current power line. Grid controlled "Thyratron" tubes are utilized for power controlled stepless variation to supply motor armature power. Patented feedback, or "Servo" circuits provide constant torque capability over wide speed ranges of as high as 60 to 1 in some models and a minimum of 20 to 1 in others.

Servospeed
DIV. of ELECTRO DEVICES, Inc.
4 Godwin Ave., Paterson, N. J
ARmory 4-8989

Circle 503 on Page 19

Bridgeport Ultra Fine Grain Brass Strip Saves Siesta-Ware $2,400 a Year

Colorful Siesta-Ware is designed to create a holiday mood ... and so are the remarkable production savings realized by Benner Glass Company!

Before Benner Glass Company, Jacksonville, Fla., made the happy discovery of Bridgeport Ultra Fine Grain Brass Strip, production of the brass banding on each attractive Siesta-Ware Party Mug, Snack Jar and Tumbler was at the rate of two coils of strip running at 35 lineal fpm through three buffing stages. Today, with Bridgeport UFG Strip, the same machine runs *at the rate of 48 fpm!*

There's a simple reason why Benner Glass now realizes 23% time savings and 8% savings on polishing materials. It is this: the infinitely superior finish of Bridgeport Ultra Fine Grain Strip requires far less buffing. Important savings in time, cutting compound and buffing naturally result. In the annual processing of Bridgeport coiled strip, Benner saves more than $2,400 ... while turning out an even better finished product!

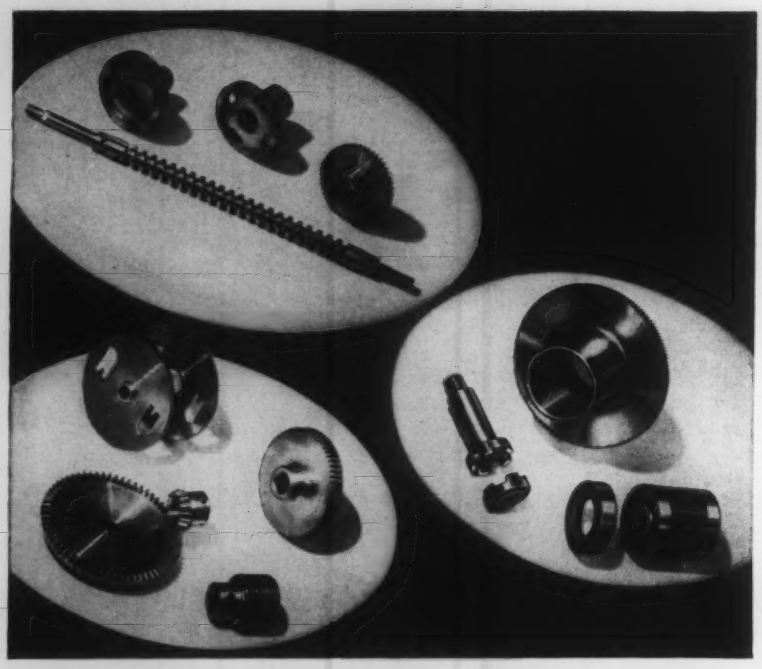
Don't *you* overlook the sizable savings that can be yours when you switch to Bridgeport Ultra Fine Grain Brass Strip. To get the facts and figures as they apply to your products, call *your* nearby Bridgeport Sales Office ... or write direct for a copy of our Ultra Fine Grain Brass Booklet, GRAIN SIZE, THE FOURTH DIMENSION. Dept. 4308.

Bridgeport Brass Co.

BRIDGEPORT BRASS COMPANY

BRIDGEPORT 2, CONNECTICUT

Specialists in Metals from **A***luminum to* **Z***irconium*



small and fine pitch gears for precision equipment

No matter how fine your gear requirements — Perkins can solve your problems. Perkins unique custom-gear engineering service, available to your engineering staff prior to the blueprint stage, will . . . eliminate production headaches . . . cut excessive costs. This service — recognized by leaders in the radar, electronic and missile fields, and backed by 52 years of custom gear experience — assures the precision quality needed to guarantee trouble-free operation. Don't gamble with gear performance . . . Perkins skilled personnel, together with modern up-to-date equipment guarantees fast delivery on prototypes or production runs. Call or write Perkins for complete information on custom-gear engineering and a quotation on your requirements. Then judge for yourself.

YOURS ON REQUEST
Folder showing custom gears Perkins has made (from various materials) for aircraft, automotive, precision instruments, home appliances, portable and machine tools, and other products. Includes Perkins facilities for producing various gear types and sizes. *Write today.*

PERKINS
MACHINE AND GEAR CO.

Dept. 73 West Springfield, Mass.
Telephone: REpublic 7-4751

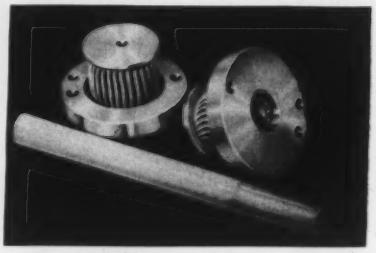
include brake, gears, and governor. Typical unit shown is 5 in. long, weighs approximately 16 oz, and includes speed reducer and brake. Motor can use 6 to 75 v dc, and provides output speeds of 6000 to 13,000 rpm. **Globe Industries Inc.**, 1784 Stanley Ave., Dayton 4, Ohio. G

Circle 648 on Page 19

Precision Filter

weighs only 1.18 oz

Small precision filter with relief valve operates at 0.3 gpm under normal conditions and at 0.8 gpm under intermittent surge. Unit which weighs only 1.18 oz, is rated at 2 mu and at 15 mu absolute. Temperature range is −65 to +275



F. Relief valve cracking pressure is 150 psi ±15. Materials used are all stainless steel. Filter can be used for hydraulic oil, corrosives, and gases. **Aircraft Porous Media Inc.**, Glen Cove, N. Y. D

Circle 649 on Page 19

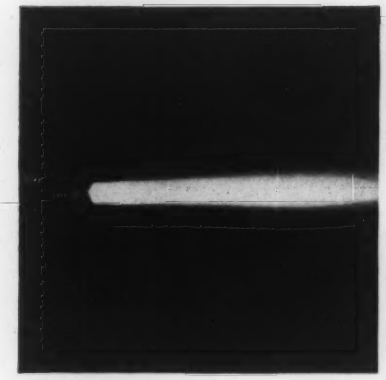
Face-Tooth Clutches

for feed, tracer, positioning drives

Face-tooth type stationary - field clutches, available in five ratings from 30 to 725 lb-ft of torque, provide high torque in small space. Units are for such applications as machine-tool feed, tracer, and positioning drives. Because of stationary-field design, clutches virtually eliminate need for maintenance in machine transmissions. Single-unit construction simplifies machine assembly and permits fast installation. Engagements are made in as little as 0.04 sec and disengagements in 0.02 sec. Fine toothing, with no flats on top, provides repetitive clutching in small increments of shaft rotation and assures that each engagement is complete.

PRODUCT-DESIGN BRIEFS FROM DUREZ

- **Phenolic for a rocket motor**
- **Heat-stable, moisture-stable insulation**
- **Compounds for dip coating**



REDSTONE DIV., THIOKOL CHEMICAL CORP.

It's warm in there

That's the exhaust pattern of a solid-propellant rocket motor. Temperature inside sometimes hits 6000°F.

At the nozzle, fuel-burning releases its full fury. To keep the bird's metal skin from buckling under the combined heat and stress, rocket engineers line many nozzles with a glass-reinforced phenolic, *Durez 16771*. During flight this plastic liner chars—at a predictable rate. It protects the metal nozzle wall from thermal failure.

Equally dramatic, if less spectacular, are the design improvements that *16771* is making possible because of its impact strength (up to 15 ft.-lb./in. Izod) and other properties. One manufacturer molds it into a rugged pump base that won't corrode and that outwears many metals. The U. S. Signal Corps puts its strength to work in boxes that protect the parachutes on droppable radios. Automotive engineers save two-thirds of the cost of automotive oil-pump gears by replacing metal with *16771*—and get gears that run almost three times as long as before.

New bulletin: To help you evaluate *Durez 16771*, we'll be glad to send you Bulletin D203. It gives a good idea of the properties you can expect, discusses current applications, and includes helpful advice on molding, machining, and finishing. If you'd like a copy, just check the coupon.

Insulation at close range

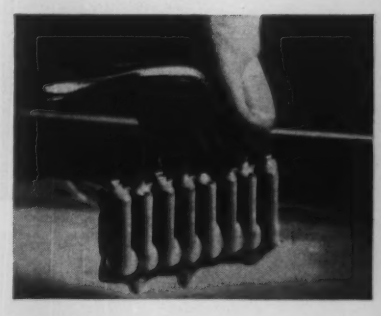
The push for good, compact insulating materials grows stronger. More electronic engineers are cramming more performance into fewer cubic inches than ever before. Under these conditions, cost of an insulator means little—when a pound of the *right* one will make smaller components, and perhaps twice as many of them.

Such a material is *Durez 16694* diallyl phthalate molding compound. We believe it to be the cream of the current plastics crop for molding components and larger parts in which circuits must function with sterling reliability despite heat, moisture, electrical and mechanical stress, and narrow working quarters.

This orlon-filled compound molds well, is not brittle, machines easily with little wear on tools. Its molding characteristics are unvarying from shipment to shipment.

It produces pieces that have very high arc resistance, consistently reproducible. It retains dimensional stability and high insulation values over extended periods at relative humidities above 90%. It does not corrode metal contacts and is virtually free from cold flow and creep.

Durez Bulletin D400 lists the properties of this compound and other electrical-grade materials. The data sheet on *Durez 16694* diallyl phthalate goes into detail on electrical test results. To get both pieces, check the coupon.



Helping resistors resist

Problem: Find a coating material that keeps tiny components like these protected against humidity—and won't peel back under the heat of a soldering gun.

Solution: A dip-coating compound based on Durez phenolic resins.

This thermosetting compound goes on smoothly without running or sagging. It's just porous enough to take a protective wax sealing coat. It cures hard, to allow stamping or color coding. It doesn't migrate or peel back during soldering.

Durez research men worked closely with electronic engineers for more than seven years to develop compounds like this. Improved each year, Durez dip-coating compounds are the most widely used of their type. A check mark on the coupon will bring you specifics about them.

For more information on Durez materials mentioned above, check here:

- ☐ *Durez 16771*, impact phenolic (Bulletin D203)
- ☐ *Durez 16694*, diallyl phthalate (Bulletin D400 and data sheet)
- ☐ Phenolic resin compounds for dip coating
- ☐ "Durez Plastics News," mailed periodically, shows and describes latest uses of Durez materials.

Clip and mail to us with your name, title, company address. (When requesting *samples, please use business letterhead.)*

DUREZ PLASTICS DIVISION

511 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICAL CORPORATION

HOOKER CHEMICALS PLASTICS

Circle 506 on Page 19

That's what the Germans call the stratosphere trails of high altitude rockets. Soon, Mach 4-5 aircraft will be cutting frozen lightning trails across our own skies. Structural parts of hypersonic aircraft and missiles must function perfectly at temperatures too high for ordinary alloys.

The answer lies in predictable performance Carpenter alloys made by the exclusive Mel-Trol®, VacuMeltrol®, and Consumet® melting processes. Engine builders find them ideal for many critical parts. Forge shops report improved forgeability resulting in better finishes requiring far less machining . . . fewer rejects.

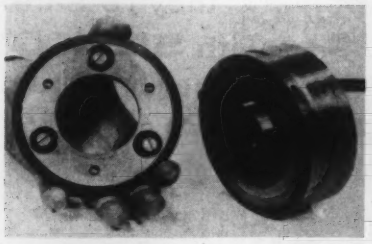
For the whole story about Carpenter predictable performance high temperature alloys, call your local Carpenter Representative or write: The Carpenter Steel Company, 120 W. Bern Street, Reading, Pa.

a new company 70 years old

Carpenter steel

The Carpenter Steel Company, Main Office and Mills, Reading, Pa.
Alloy Tube Division, Union, N.J.
Webb Wire Division, New Brunswick, N.J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.

Circle 507 on Page 19



Clutches are available for either 24 or 90-v dc operation. Power is supplied through 18-gage, neoprene-coated wire to magnet body. **I-T-E Circuit Breaker Co.**, 1900 Hamilton St., Philadelphia 30, Pa. C

Circle 650 on Page 19

Dry Lubricant

for −300 to +1000 F temperatures

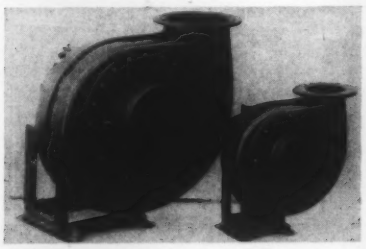
Multipurpose dry lubricant, Ever-Lube 811, exhibits wear life superior to current dry-lubricant standard for room-temperature testing in a range from −300 to +1000 F at bearing loads to 50,000 psi. Lubricant is a completely inorganic coating suitable for cryogenic use. It is noninflammable and nontoxic, and does not require extreme temperature cure. **EverLube Corp. of America**, 6940 Farmdale Ave., North Hollywood, Calif. L

Circle 651 on Page 19

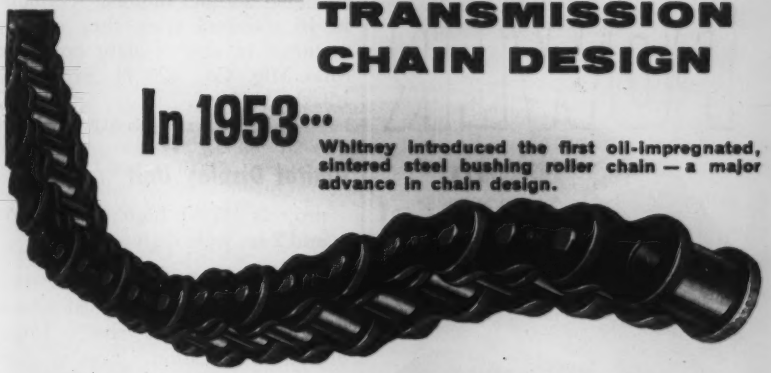
PVC Blowers

have low-pressure polyethylene fan wheels

PVC blowers incorporate injection-molded or welded fan wheels of low-pressure polyethylene. Blower cases are pressed PVC and cover plates are fastened by stainless-steel screws and nuts. All blowers are equipped with iron pedestals and motors. Smaller sizes are directly connected with integral motors, while larger units are equipped with driving belts. They are also



PROGRESS IN POWER TRANSMISSION CHAIN DESIGN

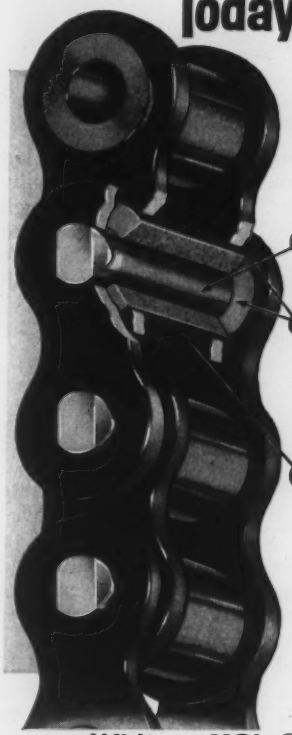


In 1953...

Whitney introduced the first oil-impregnated, sintered steel bushing roller chain — a major advance in chain design.

Not content with leading the field with the first sintered bushing chain, Whitney Engineers continued their exhaustive field research... carried on searching studies of the original sintered bushing chain in an effort to produce an even better chain with optimum performance characteristics. Their work, coupled with recent developments in sintering technology, resulted in the development of MSL Chain—a completely new concept in power transmission chain.

Today...



WHITNEY MSL* CHAIN... a product of continuing Whitney Research—is another giant step forward in chain technology because it advances and improves on the basic idea of oil-impregnated, sintered steel bushings in power transmission chain.

Only Whitney MSL Chain with oil-impregnated bushings assures complete built-in lubrication at all three critical lubrication areas:

1. **Pin**—Protective film of oil completely lubricates the live bearing area between pin and bushing, minimizing wear by reducing metal-to-metal contact.
2. **Plates**—Whitney oil-impregnated sintered steel bushings extend beyond surface of inside plates to act as lubricated thrust bearings, control clearance, and provide an oil cushion between plates, eliminating plate galling and seizing frequently caused by misalignment of sprockets.
3. **Sprocket Engagement**—MSL Chain does not require rollers, as the tough oil film on the bushing surface provides smooth sprocket engagement, cushions impact and reduces drive wear.

Inherent material characteristics of Whitney sintered steel bushings, plus bushing configuration that provides greater contact area between bushings and links, permit high interference fit, which pre-loads links and gives maximum fatigue resistance.

Whitney MSL Chain meets ASA Standards

It is made in Standard and Extended Pitch types, and is completely interchangeable with any similar pitch ASA Standard chain. For full details, write for MSL Catalog G1-59, or call your nearby Whitney Chain Distributor, who carries MSL Chain in stock for quick delivery.

***Maximum Service Life**

Whitney *Advanced Design is a Whitney Tradition*

CHAIN COMPANY

A Subsidiary of Foote Bros. Gear and Machine Corporation

4567 S. WESTERN BOULEVARD
CHICAGO 9, ILLINOIS

put HEINZE in your designs

POWER

in compact size...

HEINZE UNIVERSAL MOTORS

When you want power in compact series motors, Heinze Universal Motors provide high starting torque, variable speed, reversibility and high output. Originally developed for sewing machines and office machines, they are extremely flexible in design for a variety of uses not requiring constant speed. Flat sided models are especially adaptable for limited space.

Horsepower ratings are from 1/10 to 1/30. Load speed is 7,500 rpm. Standard voltage rating is 115V, AC/DC but motors are supplied for other voltages in AC or DC. Rotation is CW, CCW, or reversing. Optional mounting arrangements include tapped holes on flat side.

Send coupon for new catalog on Heinze Universal Motors — plus the complete line of Heinze sub-fractional horsepower motors and blowers.

HEINZE ELECTRIC COMPANY
685 Lawrence St.
Lowell, Massachusetts

Heinze Electric Company
Dep't D, 685 Lawrence Street
Lowell, Massachusetts

Please send new catalog on Heinze sub-fractional motors and blowers.

Name & Title.....

Company.....

Street & No.....

City & State.....

Circle 509 on Page 19

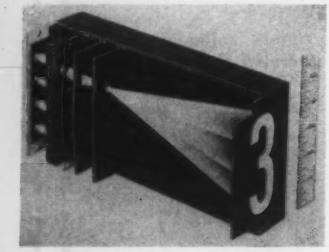
available without motors. Available in 16 standard sizes, they can be mounted in any of eight positions. **Milo Mfg. Co.**, 420 N. Broad St., Elizabeth, N. J. D

Circle 652 on Page 19

Digital Display Unit

projects 3¾ in. high and 2 in. wide digit

Series 80,000 in-line display unit features a three-lens optical system designed to give a sharp, bright digital presentation. Size of digit or character displayed is 3¾ in. high by 2 in. wide, and it can be seen from a distance of over 100



ft. Body case is aluminum for strength, rigidity, and durability. Unit is 3¼ in. wide, 5¼ in. high, and 11½ in. long. **Industrial Electronic Engineers Inc.**, 5528 Vineland Ave., North Hollywood, Calif. L

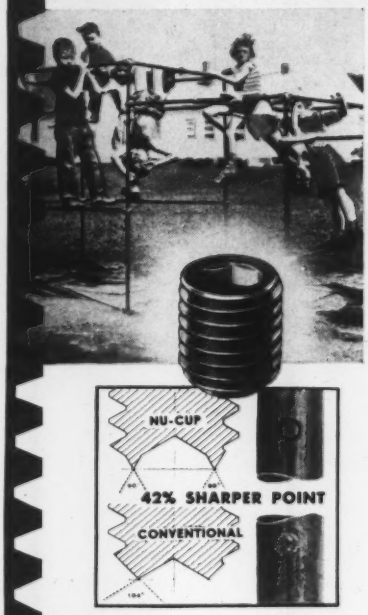
Circle 653 on Page 19

V-Belt Drives

provide size and weight savings

Ultra-V drives handle up to three times the horsepower of conventional V-belt drives occupying the same space. They save both weight and space for a drive of given horsepower. Entire range of drive requirements from 1 to 1500 hp is covered by three belt cross-sections: 3V, ⅜ in. wide x 5/16 in. deep; 5V, ⅝ in. wide x 17/32 in. deep; 8V, 1 in. wide by ⅞ in. deep. Deep, narrow belts have greater side-wall area for transmission of power. Arched tops confine tensile members, freeing side walls for compression and gripping power. Arched top also helps to hold tension members in alignment and to equalize load carried by each member. Belts are subject to little if any shelf shrinkage. All are static conduc-

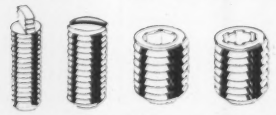
they're safe with SETKO NU-CUP* set screws on the job!



Whether it's supporting children on monkey bars or harnessing a spinning shaft you'll find NU-CUP set screws dig in deeper and hold tighter. The shaft illustrated here tells the story.

NU-CUP has a 42% sharper point which penetrates in a deep, full circle giving tremendous holding power. In some cases it actually reduces the number of set screws needed for the job.

You can get them in slabbed, slotted, hex or fluted socket.



SEND FOR FREE TEST SAMPLES and full information. Ask about NU-CUP set screws. Catalog 23 free on request.

*U.S. Pat. No. 2,778,265

SETKO Set Screw & Mfg. Co.
28 Main Street, Bartlett, Illinois

573

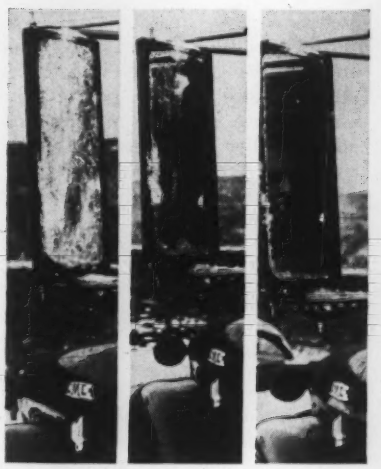
Circle 510 on Page 19

THIS IS GLASS

A BULLETIN OF PRACTICAL NEW IDEAS FROM CORNING

NEW! A MIRROR THAT MAKES HEAT TO BEAT SLEET

You're jockeying a big trailer-truck along a winding road in New England. It's winter and you run into a real storm—a mixture of snow, rain, sleet. You flip a switch and . . .



Your outside rear-view mirror is *clear* in a matter of minutes. From a heavy coating of ice to *all* clear is only a matter of five minutes, even at −20°F.

The mirror, as you might guess, isn't just ordinary glass. It's one of Corning's PYREX brand glasses, and on its surface is an electrically conductive coating that's permanently fired in.

This coating (a metallic oxide) is what turns your mirror into a *heating* element when a current is applied. The heat melts ice and snow, prevents fog or drizzle from condensing on the surface.

If you use EC (electrical-conducting) glass for self-defrosting mirrors you get a bonus, since the coating also provides a non-glare surface.

But don't go away just because you gave up dreaming about driving a truck-and-trailer years ago. This PYREX® electrical-conducting glass comes in a wide choice of applications.

For example, there are some enterprising people who build radiant heaters, both portable and permanent, around such glass panels.

Comfort, safety, and convenience are the big selling points. Comfort because a panel of EC glass is an area *heat* source putting out long waves. Safety because there are no exposed wires or moving parts. Convenience since you have no burning, no need to do extensive remodeling in order to install it.

These same reasons have made PYREX brand radiant heating units attractive to industry—for heating, drying, curing, baking.

And, if you turn a panel of this glass *around*, it becomes an infrared reflector you can see through—blocking heat but still passing about 75% of the visible light.

Facts? Ask for PE-34, a 4-page data sheet, and/or PE-60, all about industrial heating units. Please use the coupon.

HOW NOT TO FOUL UP THE WORKS

It's really very simple: If you're using spun insulation in electric motors, you have to keep the stuff from falling into the moving parts and fouling up the works.

Two things to keep in mind when selecting a material for this application: (1) It has to stand up to quite a bit of heat. (2) It *can't* be a conductor.

Some materials that are good insulators can't take the heat. Others function well at high temperatures but are not insulators.

Glass solves both problems. So, people who make electric motors build them with wedges made from PYREX brand glass No. 7740. (We supply the glass in rod form.)

This particular PYREX brand glass offers a number of useful characteristics. It is corrosion resistant and has a linear coefficient of expansion of 32.5 x 10^{-7} in/in between 0° and 300°C. Dielectric properties at 1 Mc and 20°C. are as follows:

Power factor	.46
Dielectric constant	4.6
Loss Factor	2.1

Wedges made from glass rod support spun insulation in electric motors. Glass is non-conducting and able to stand high temperature without deforming.

You can get PYREX brand glass No. 7740 in a variety of forms—pressed ware, blown ware, plate, tubing, rod and panels.

Mechanical, thermal, electrical, and chemical properties of this glass and 27 others are spelled out in Bulletin B-83. Check the coupon for a copy.

PLUMBING FOR POSTERITY

An increasingly popular fixture in labs, hospitals, schools, chem plants, and photo-engraving shops is the glass drainline.

With good reason. Glass drainlines are fashioned from PYREX brand glass No. 7740.

This is the glass that ends your worries about corrosion. For example, if you were disposing of waste hot hydrochloric acid, your PYREX pipe would still be around at the end of 200 years.

And glass is smooth; very little chance for block-up in the pipe. If such does occur, however, you can spot the exact point and take corrective action, without having to take down the whole system.

In fact, almost anything made from PYREX brand glass No. 7740 will be around for quite a while because this glass is able to cope with thermal shock and physical knocks, too.

Available in many forms—tubing, rod, pipe, plate, and all kinds of shapes.

Fill in the gaps in your files with these basic references: PE-30, all about glass drainlines; IZ-1, design considerations in glass. Any or all, free. Use the coupon.

MORE ON PYROCERAM*

Developments in our new crystalline materials made from glass are treated at length in the third Pyroceram Progress Report. See coupon.

*Trade Mark

CORNING MEANS RESEARCH IN GLASS

CORNING GLASS WORKS 52 Crystal St., Corning, N. Y.

Please send me: ☐ PE-60, booklet on heating units; ☐ B-83, "Properties of Selected Commercial Glasses"; ☐ IZ-1 Design Manual; ☐ PE-30 Drainline Manual; ☐ Pyroceram Progress Report No. 3; ☐ PE-34, "Corning Flat Glasses."

Name ..... Title .....

Company .....

Street .....

City ..... Zone ..... State .....

ATLAS
Electrolized ROLLER CHAIN

RESISTS CORROSION

Corrosion resistance compares favorably with any other corrosion resistant chain in most applications.

LASTS LONGER

Actual wear-drive tests prove it lasts longer than alloy steel chain and much longer than stainless steel or other corrosive resistant chains. Has higher tensile strength . . . lower coefficient of friction.

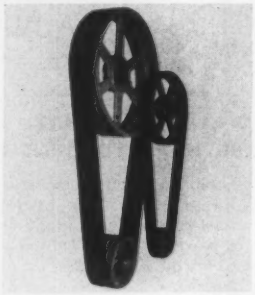
COSTS LESS

Atlas Electrolized Roller Chain is as much as 40% lower in price than any other corrosion resistant chain.

From the standpoint of cost, efficiency and longer wear Atlas Electrolized Roller Chain allows you to specify corrosion resistant chain on drives previously ruled out due to high cost and short chain life. Write for technical specification folder to . . .

ATLAS CHAIN & MANUFACTURING COMPANY
West Pittston, Pa.

ATLAS ROLLER CHAIN



tors and resist heat, oil, and outdoor exposure. They are available in premium grade only. Matching sheaves have narrow grooves and close groove spacing, making possible smaller diameters and lesser weights. **T. B. Wood's Sons Co.**, 1200 Fifth Ave., Chambersburg, Pa. E

Circle 654 on Page 19

Zippered Tubing

for use in high temperatures

Aluminized, silicone-rubber-impregnated, glass-cloth Zippertubing has excellent chemical resistance and can be used safely to shield and jacket cables around penetrating aircraft hydraulic fluids. Tubing is for use in temperatures between 250

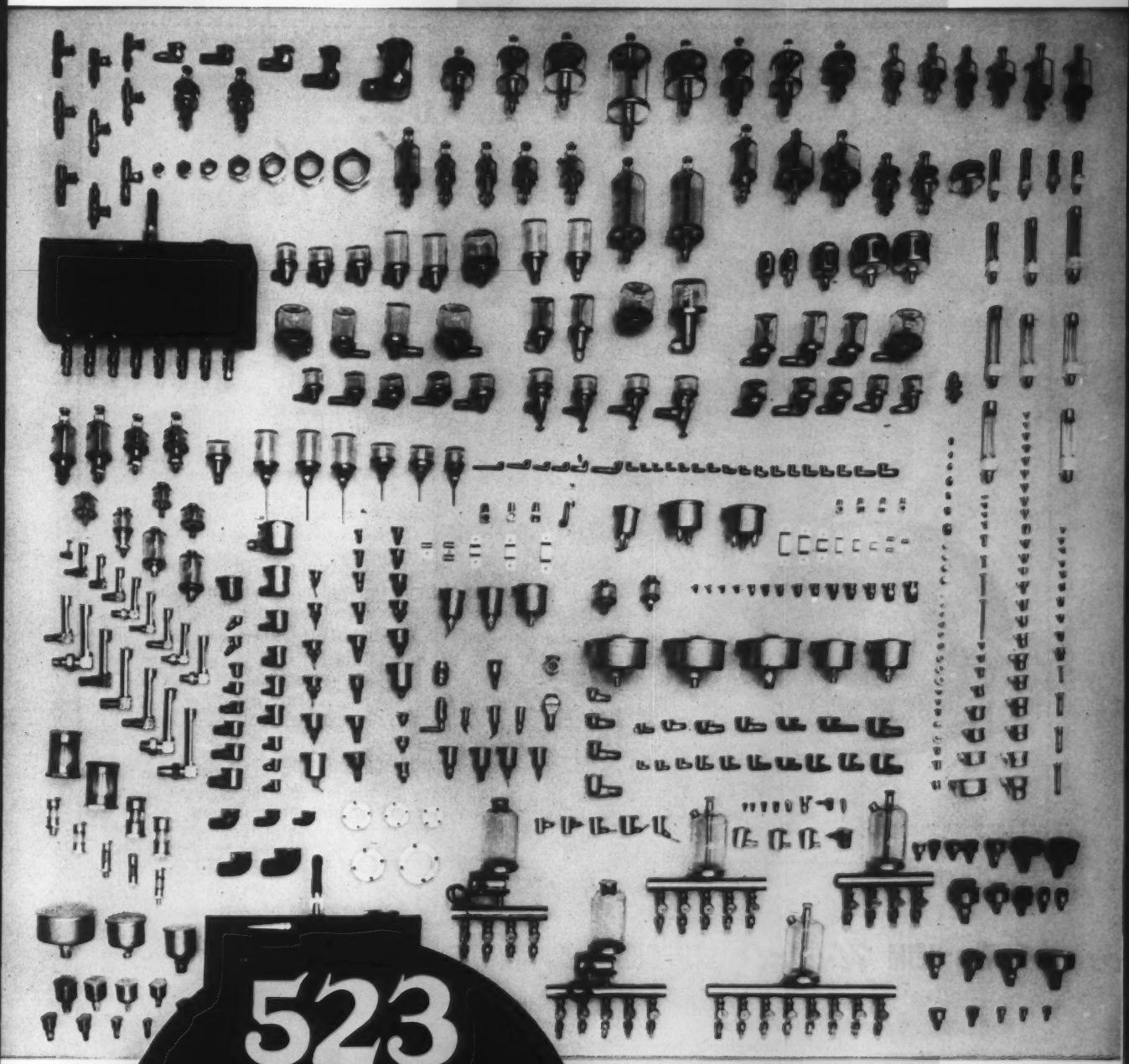
and 600 F, and has excellent heat-reflective qualities. **Zippertubing Co.**, 752 S. San Pedro St., Los Angeles 14, Calif. L

Circle 655 on Page 19

Nylon Stop Nuts

one-piece units are washer-faced

Brilok nylon stop nuts are simultaneously self-tapping, locking, sealing, and insulating. One-piece, washer - faced, resilient hexagon units are composed entirely of Zytel 101 nylon resin and are molded to



523 GITS OILERS AND GAUGES READY TO SHIP

Largest selection available anywhere. You save time and money, because the one you want is always right in stock. Send for complete Catalog.

Specialists in Lubricating Devices and Shaft Seals for Almost Half-A-Century

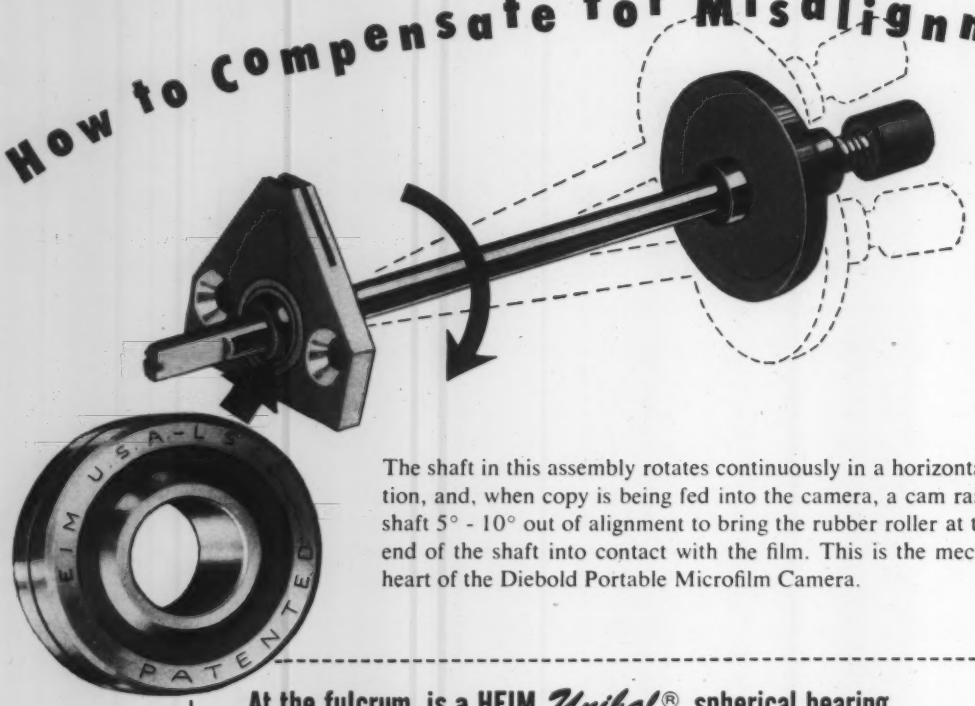
GITS BROS. MFG. CO.

1868C S. Kilbourn Ave., Chicago 23, Ill.

Circle 513 on Page 19

This application shows...

How to compensate for Misalignment

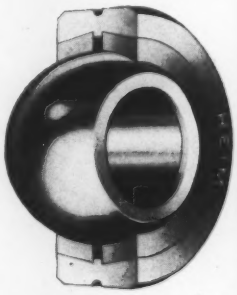


The shaft in this assembly rotates continuously in a horizontal position, and, when copy is being fed into the camera, a cam raises the shaft 5° - 10° out of alignment to bring the rubber roller at the free end of the shaft into contact with the film. This is the mechanical heart of the Diebold Portable Microfilm Camera.

At the fulcrum, is a HEIM *Unibal*® spherical bearing

This self-aligning bearing not only compensates for the inherent misalignment of the shaft, but delivers the smooth operation which prevents hesitation or binds that would show up as objectionable density bars in the picture.

The HEIM *Unibal*® SPHERICAL BEARING

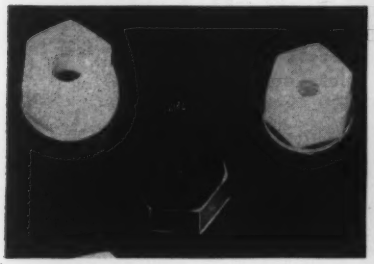


represents a simple, trouble-free self-aligning bearing principle. This cutaway view shows how the single ball has universal movement, rotating in bronze bearing inserts, and presents a large surface supporting area. This permits higher load ratings to meet virtually every application requirement.

Heim Unibal Bearings are sold and stocked by the leading bearing distributors in the U.S. and Canada. Write for complete catalog and list of distributors/ or for any engineering data on special problems.

THE HEIM COMPANY

FAIRFIELD, CONNECTICUT



American Standard Flats width dimensions, allowing for use of standard installation and removal tools. Nuts are suitable for use on many types of equipment, including aircraft, automotive, railroad, marine, electronic, chemical, business, medical, photographic, and household. They are recommended for applications where toughness, extreme light weight, form stability at high temperatures, abrasion resistance, corrosion resistance, and strength in thin sections are required. Units lock at any position along shank of screws, permitting presetting. **Pheoll Mfg. Co. Inc.**, 5700 W. Roosevelt Rd., Chicago 50, Ill. J

Circle 656 on Page 19

Gate Valves

of one-piece, lightweight construction

Gate valves feature mechanically loaded and retained Teflon seals, roller-type clutches, and interchangeable actuators. Valves are easily adaptable to custom specifications including variations in electrical connectors, thermal characteristics, adaptation to most fuels, gases, and liquids used in the aircraft and missile industries, unique operating times, inclusion of radio filters, and special-application valve-body configurations. Valves are of one-piece, lightweight construction and feature through-mounted bolts. Teflon is used in all dynamic seals. Seals can be removed quickly as a complete subassembly without neces-

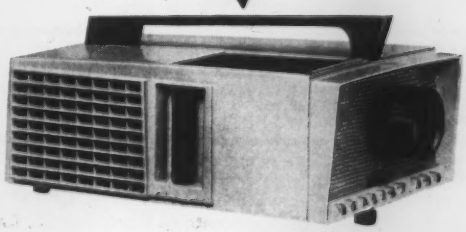
this lens magnifies sales

There's a mass-market price tag on this new Realist 620 color slide projector. Easy to see why: Realist used a low-cost aspheric lens by Lancaster—for a brighter sales picture.

Want lower unit costs for your product? Let Lancaster design the glass and plastic components.

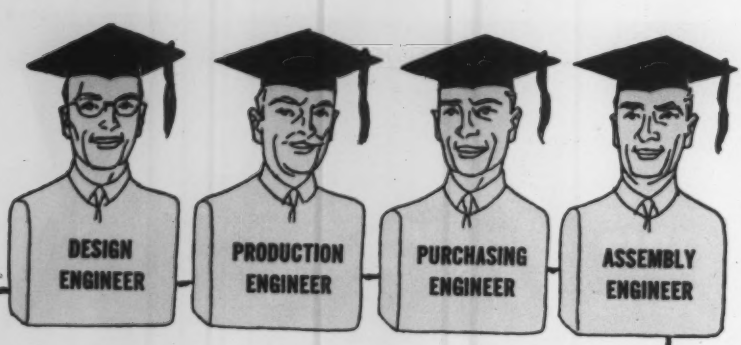
design flexibility in glass

Lancaster
glass and plastics
to brighten your product's future



LANCASTER GLASS CORPORATION
LANCASTER 2, OHIO

Circle 515 on Page 19



THOSE IN THE KNOW, KNOW

There's **NO** time waste

There's **NO** machining

There's **NO** grinding

There's **NO** counting

There's **NO** stacking

There's **NO** miking

and there's NO dirt between layers—ever, for those who say

YES to...

Laminated Shims of **LAMINUM** now available in

LAMINUM®
the solid Shim that p-e-e-l-s for adjustment

Send for free copy "Engineering Data File"

STAINLESS STEEL	ALUMINUM	BRASS	MILD STEEL
with laminations of .002" or .003"	with laminations of .003" or NEW .002"	with laminations of .002" or .003"	with laminations of .002" or .003"

LAMINATED SHIM COMPANY, INC.

EAST COAST Home Office and Plant
1211 Union St., Glenbrook, Conn.

WEST COAST Sales Office
600 Sixteenth St., Oakland 12, Calif.

Circle 516 on Page 19

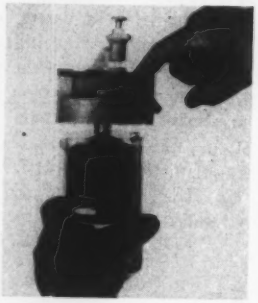
sity of disassembling springs or loading devices. Fuel provides complete lubrication for valve. **Whittaker Controls Div., Telecomputing Corp.**, 915 N. Citrus Ave., Los Angeles 38, Calif. L

Circle 657 on Page 19

Air-Line Lubricator

has quick-change bowl

Auto-Fill Micro-Mist air-line lubricator is designed so that a touch of the finger releases the lock. Simultaneously and automatically, a valve bleeds air from bowl. Bowl comes off without use of tools and without removing extra parts such as screws,



clamps, or rings. Maximum air pressure is 150 psi, and maximum oil pressure, 250 psi. From one point, an unlimited number of bowls can be filled automatically. **Wilkerson Corp.**, 1646 W. Girard, Englewood, Colo. K

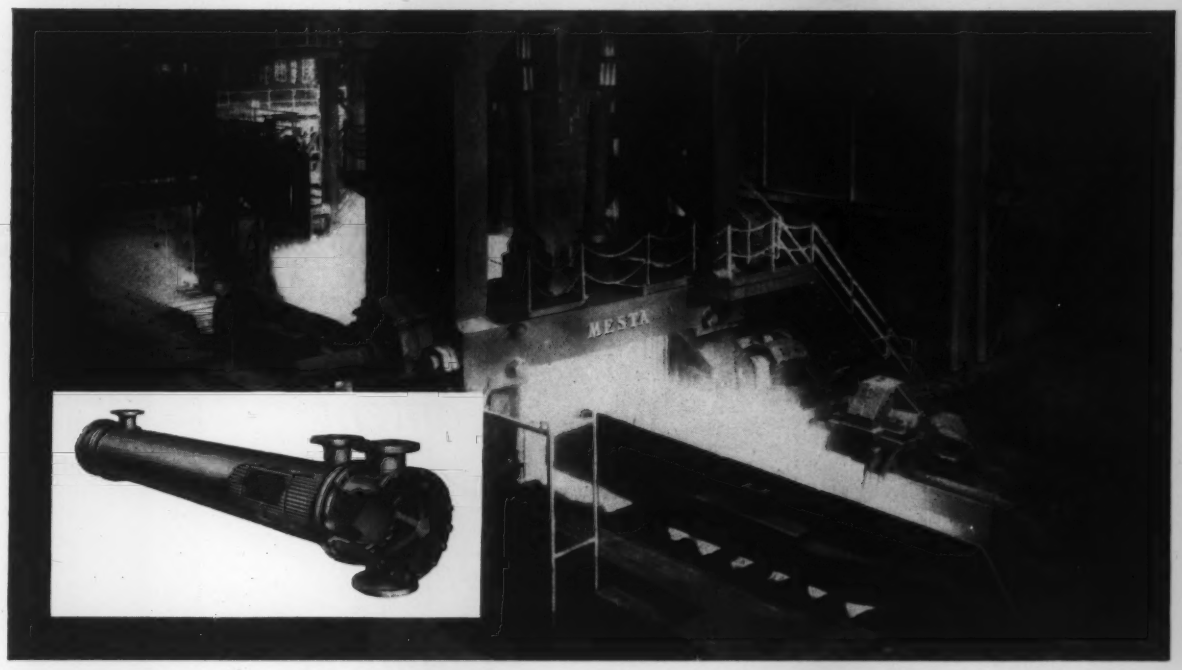
Circle 658 on Page 19

Hysteresis Motor

has high torque capabilities

Supersyn hysteresis motor is suited for use in applications where small size and light weight, in conjunction with low speed, are required. Design features provide high torque capabilities, extremely fast acceleration, and very good damping. Size of motor, in multipolar designs, is only a fraction of the size of conventional multipolar hysteresis motors. For example, a 12-pole Supersyn unit can be one-fourth the size of a conventional hysteresis motor and develop the same output. Torque in Supersyn motor of a given size increases with number of poles, while in a conventional hysteresis motor it is constant, irrespec-

lube oil cooled by Ross Exchangers



Blazing ingots thinned to glowing slabs in this Mesta Mill

HEAVY SHOCK LOADS, scorching heat and continuous operation — they're all part of the job as this Mesta Universal Reversing Slabbing Mill rolls red hot steel ingots into slabs.

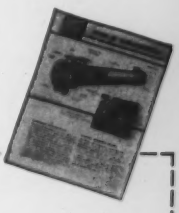
UNDER THESE SEVERE conditions where working temperatures of gears and bearings will often exceed 200°F., temperature-safe lubrication is a prime requirement. Even a lubrication failure at a minor point could shut down the entire mill.

THAT'S WHY Mesta selected two Ross Type CP Exchangers to provide dependable cooling of the circulating oil. Roll neck bearings, main drive gears and all hard working parts are given continuous protection by oil at the right temperature and right viscosity.

THROUGHOUT the metal industry, Ross Exchangers are counted on to safeguard the performance of engines, compressors, extrusion presses, metal drawing presses, welders, die casting machines, speed changers and other prime equipment. They're top-rated for thermal efficiency and ruggedness.

COMPACT IN DESIGN, easy to install and easy to maintain, Ross Exchangers are pre-engineered and fully standardized in a wide range of sizes to meet your heat transfer requirements.

For detailed information, send coupon below requesting Bulletin 2.1K5.



TO:
American-Standard*
Industrial Division
Detroit 32, Mich.

MD 514-59

Please send, without obligation, your Bulletin 2.1K5 describing Ross Type CP Exchangers.

NAME _____

TITLE _____

COMPANY _____

ADDRESS _____

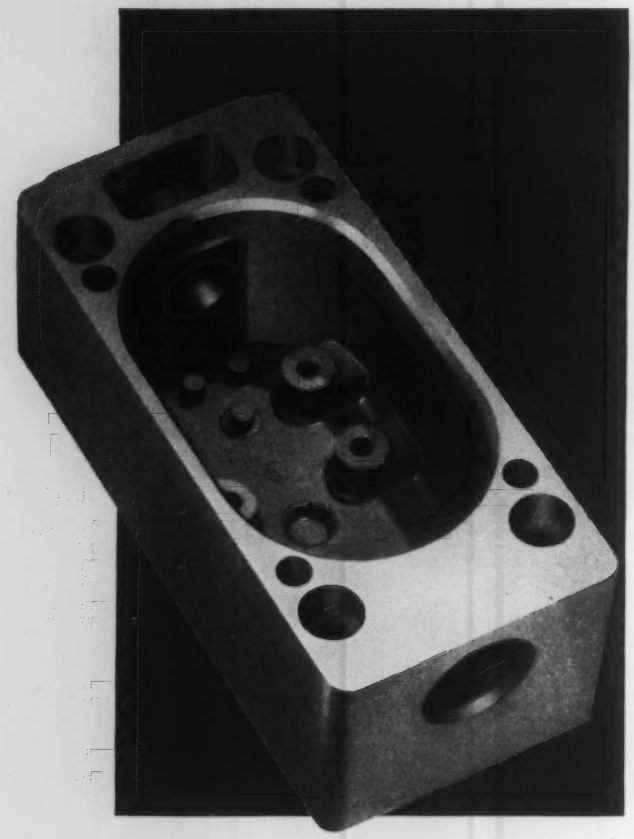
CITY _____ ZONE _____ STATE _____

*American-Standard and Standard ® are trademarks of American Radiator & Standard Sanitary Corporation.

AMERICAN-Standard
INDUSTRIAL DIVISION

AMERICAN BLOWER PRODUCTS • KEWANEE PRODUCTS • ROSS PRODUCTS

Circle 517 on Page 19



Low Labor Content is the Design Emphasis Today

with MADISON-KIPP zinc and aluminum die castings

In the Micro Switch Housing illustrated, the sintered bearings are cast in place, the holes are ready for tapping, the lugs and mounting pads are cast to size.

This is a prime example of maximum utilization of the die casting process.

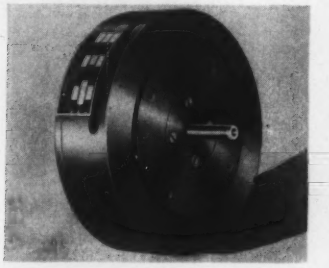
The skilled and cost-conscious mechanics at Madison-Kipp worked closely with the switch designer to create a component of excellence and low secondary labor content.

Please clip this ad as a reminder to contact us when you have die casting requirements.

kipp

MADISON-KIPP CORPORATION
210 WAUBESA STREET • MADISON 10, WIS., U.S.A.

Skilled in Die Casting Mechanics • Experienced in Lubricating Engineering • Originators of Really High Speed Air Tools



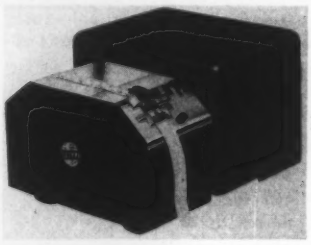
tive of number of poles. **Bekey Div., Genisco Inc.**, 2233 Federal Ave., Los Angeles 64, Calif. L

Circle 659 on Page 19

Punched-Tape Reader Set

miniaturized unit has many applications

Punched-tape reader set, including transmitter-distributor, motor, base, and cover, is 40 per cent smaller in size and weight than previous models. Designated Model 28 miniaturized LXD set, it is 5⅞ in. high, 7½ in. wide, and 9½ in. deep. Unit provides facilities for sequential (serial) output, 100-word-per-minute transmission, and reduced power requirements. Optional contacts are available for multiwire output.



Models are available to read five or six-level chadless or fully perforated tape. Wide range of tape-reading applications includes on-line data transmission over existing communications facilities, and off-line control of tape-operated factory or office machines. **Teletype Corp.**, Dept. SP-8, 4100 Fullerton Ave., Chicago 39, Ill. J

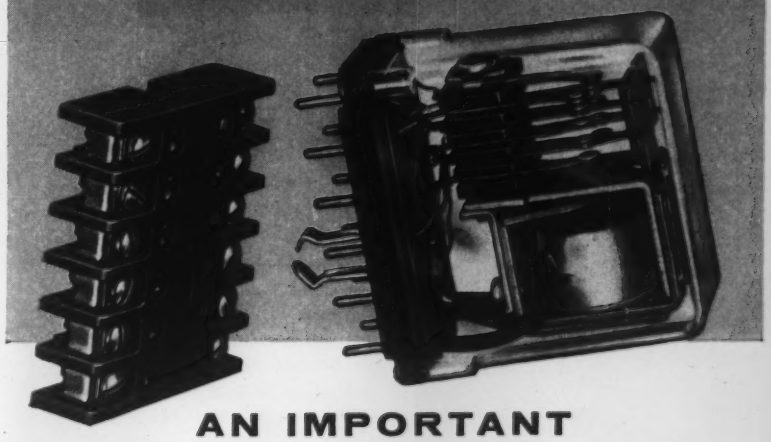
Circle 660 on Page 19

Ball Valves

are vinyl except for seats and seals

Rigid vinyl ball valves are for use in piping systems where corrosion is a problem. Except for seats and

Dunco's answer to the problem of "over-relayed" industrial controls!



AN IMPORTANT

RELAY

for industrial control

219 Frame Relays, using heavy duty 12-pin plugs and sturdy industrial-type phenolic sockets, are Dunco's answer to the need for industrial control relays that are large enough, but not too large; fully dependable, but moderately priced. Designed for long, reliable contact life on relaying loads, they have proved outstandingly successful on laboratory-type "tail chasing" circuits and on machine control installations.

Dunco 219 Frame Relays have 10-ampere current carrying parts; 150-volt electrical spacings of ¼" over surface and ⅛" through air; and withstand 1500-volt dielectric test. Three standard contact arrangements available at *minimum* prices facilitate control circuitry standardization and simplify field maintenance replacement problems.

Write Today for Dunco Engineering Bulletin 2219.

Member, National Assn. of Relay Manufacturers

STRUTHERS-DUNN

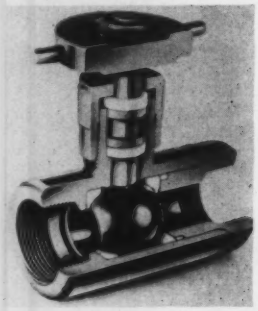
World's largest selection of relay types

STRUTHERS-DUNN, Inc., Pitman, N. J.

S-D

Sales Engineering offices in: Atlanta • Boston • Buffalo • Charlotte Chicago • Cincinnati • Cleveland • Dallas • Dayton • Detroit Kansas City • Los Angeles • Montreal • New Orleans • New York • Pittsburgh • St. Louis • San Francisco • Seattle • Toronto

Circle 519 on Page 19



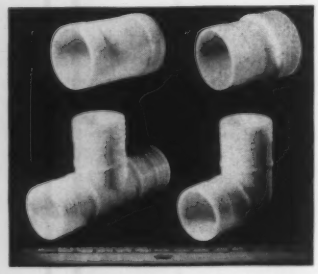
seals, valves are made of Geon vinyl material. They provide superior resistance to oils, acids, alkalies, and most chemicals. Available with threaded ends, weld ends, or flanges, vinyl valves are self-compensating for changes in pressure or temperature. There is no problem of galling or seizure, and no lubrication is needed. **Jamesbury Corp.**, 45 New St., Worcester, Mass. B

Circle 661 on Page 19

Pipe Fittings

nylon units are available in sizes to 4 in.

Insert-type fittings molded of nylon for use on plastic pipes are now available in sizes from ½ to 4 in. Strong, lightweight fittings have high tensile and impact strength.



Corrosion resistance is superior to that of conventional metal fittings. **Plastiline Inc.**, 2 Intervale St., White Plains, N. Y. D

Circle 662 on Page 19

High-Temperature Transformer

is only 1 3/16 in. thick

Thin-Tran 120-w, high-temperature transformer requires small chassis mounting space. Unit is only 1 3/16 in. thick, made possible by use of widely distributed, shallow windings of high-temperature wire

Ring Seals by LINEAR

in Kel-F, Viton-A, Vyram, Polyurethane, and other unusual elastomeric materials having excellent resistance to many petroleum oils, synthetic lubricants, fuels, phosphate and silicate ester fluids—in a temperature range of —40° to +500° F.

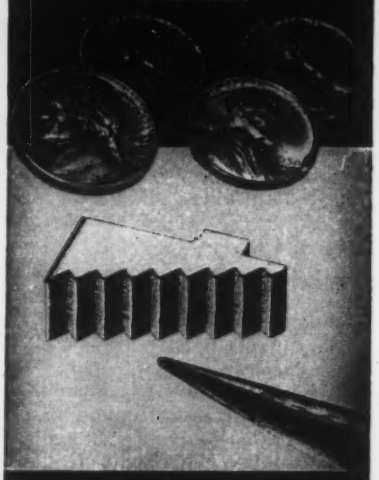
LINEAR—specialists in close-tolerance molding in all of today's modern polymers . . . in both fabric reinforced and homogeneous materials.

These are automatic seals. For further help, call the LINEAR engineer.

PERFECTION IN RUBBER
LINEAR
LINEAR, Inc., STATE ROAD & LEVICK ST., PHILA. 35, PA.

Circle 520 on Page 19

Only 8 Cents
. . . for this intricate Minicast part . . .



in quantities of 100,000

Here is another dramatic example of the benefits to be gained from the new Minicast precision process. In addition to an unusually low per unit cost for the part, strict specifications had to be met.

For example, the Minicast process had to provide

- an average maximum radius of .003 on the teeth
- specific tolerances of plus or minus .001
- no tolerance greater than plus or minus .003
- and produce the parts in non-machinable stellite

If you use intricate parts in similar quantity ranges, chances are the Minicast process is your answer to lower costs.

Get the complete story . . . Write for this new descriptive brochure . . . it's free of course

Casting Engineers

2321 NORTH BOSWORTH AVENUE
CHICAGO 14, ILLINOIS

Circle 521 on Page 19

BEING INTEGRATED INTO TOMORROW'S AIRCRAFT AND MISSILE SYSTEMS

NEW VICKERS Variable Displacement Hydraulic Pumps with MAXIMUM HP/LB RATIO

Model Series	Displacement cu. in./rev.	RPM		Weight lb.	HP/LB*	
		Limited Life	Rated		Limited Life	Rated
PV006	.095	18,200	12,500	2.8	4.55	3.12
PV012	.188	14,500	10,000	4.5	4.45	3.06
PV024	.367	11,600	8,000	6.9	4.53	3.13
PV039	.600	10,000	8,000	10.2	4.33	3.46
PV062	.950	8,900	7,000	14.0	4.44	3.49
PV104	1.600	7,500	5,800	19.0	4.65	3.59
PV163	2.500	6,500	5,100	26.0	4.60	3.60

***This is hydraulic output horsepower at 3000 psi**

The above table is important to anyone concerned with the selection of hydraulic pumps for future air or space vehicles. Note particularly the horsepower-to-weight ratios for both rated and limited life speeds. These are the highest known available at this time.

But highest hp/lb is only one of many advantages offered you by the new Vickers advanced design variable displacement pumps. Developed to meet the requirements of the new MIL-P-19692 specification, this new series has volumetric efficiencies of 96% to 98% over a pressure range of 500 to 3000 psi . . . and has 4000 psi continuous operation capabilities. These pumps have faster response and improved contamination resistance; they have practically the same envelope as constant displacement units of equal output. The first five sizes are now being integrated into advanced aircraft and missile systems; the two larger sizes are in the development stage. Write for Bulletin A-5233 for additional information.

Variable Hydraulic Motors using the Advanced Design Series concept are now under development.

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Aero Hydraulics Division — Engineering, Sales and Service Offices:
ADMINISTRATIVE and ENGINEERING CENTER—Department 1430 • Detroit 32, Michigan
TORRANCE, CALIFORNIA—3201 Lomita Blvd., P.O. Box 2003 • Torrance, Calif.

Aero Hydraulics Division District Sales and Service Offices:
Albertson, Long Island, N.Y., 882 Willis Ave. • Arlington, Texas, P. O. Box 213
Seattle 4, Washington, 623 8th Ave. South • Washington 5, D.C., 624-7 Wyatt Bldg.
8332 ***Additional Service facilities at:*** **Miami Springs, Florida, 641 De Soto Drive**
TELEGRAMS: Vickers WUX Detroit • TELETYPE: "ROY" 1149 • CABLE: Videt
OVERSEAS REPRESENTATIVE: The Sperry Gyroscope Co., Ltd.—Great West Road, Brentford, Middx., England

Engineers and Builders of Fluid Power Equipment Since 1921

Circle 522 on Page 19

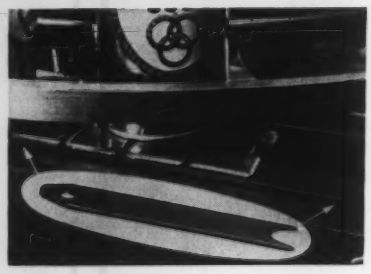
NYLATRON® G S

Gives the property advantages of nylon, PLUS... improved mechanical characteristics:

- Greater Rigidity—higher modulus of elasticity, less deformation under load.
- Higher Heat Distortion Temperatures—distortion temperatures 70% higher than nylon 101.
- Lower Thermal Expansion—coefficient approximately 60% of nylon 101.
- Low Surface Friction—can be used without lubrication.
- High Wear and Abrasion Resistance —can outlast, outperform metal.

NYLATRON GS, a molybdenum disulphide filled nylon*, is formulated to expand the field for nylon parts such as bearings, bushings, liners or other wear parts. Its superior mechanical and thermal characteristics coupled with the chemical and electrical properties of nylon result in a material with proven advantages. It is produced under controlled manufacturing standards to assure the ultimate in uniformity, quality and reliability.

Stock shapes of NYLATRON GS include rod, strip, tubing, tubular bar and plate in all standard sizes—for rapid, low-cost fabrication on standard metalworking tools. In addition, it is available in powder form for molding.



NYLATRON GS wear strips provide excellent wear cushion between metal bottling chain and conveyor stands. Due to inherent wear resistance and low surface friction, NYLATRON outwears metal strip while reducing wear on chain and stand.

Polymer can also supply stock shapes of all commercial nylons on request.

Write today for detailed information about NYLATRON GS—or other nylon formulations to meet your specific requirements.

*Patents applied for

THE POLYMER CORPORATION OF PENNA.
Reading, Pennsylvania
Export: POLYPENCO, INC., Reading, Pa., U.S.A.

POLYPENCO

POLYPENCO Nylon, POLYPENCO Teflon†, NYLAFLOW® and NYLATRON® GS †DU PONT TRADEMARK

providing short thermal path. Fully encapsulated and hermetically sealed in a steel container, transformer meets MIL-E-5272C and MIL-T-27A, Class S. Standard unit operates at 115 v, 400 cps, and is available with secondary voltages from 5 to 2000 v. Ambient temperature range is −55 to +100 C. Unit weighs 15 oz and provides power-to-weight ratio of 125 w per lb. **Arnold Magnetics Corp.**, 4613 W. Jefferson Blvd., Los Angeles, Calif. L

Circle 663 on Page 19

Synthetic Rubber

has excellent resistance to temperature, chemicals

New type of Viton synthetic rubber offers significant improvement in performance after exposure to extremely high temperatures and to certain solvents, oils, and chemicals. Heat-aging tests at temperatures in 500 to 600 F range demonstrate better retention of elongation and less change in hardness than previously possible with other commercial elastomers. Superior performance is exhibited in contact with diester lubricants such as specified in MIL-L-7808, phosphate ester hydraulic fluid, tricresyl phosphate, and benzene. Vulcanizates of the improved rubber have higher modulus-equivalent elongation and higher hardness than previous types. Product will not support combustion. **E. I. du Pont de Nemours & Co.**, Wilmington 98, Del. C

Circle 664 on Page 19

Footswitches

have more than five switch arrangements

Model Y15A footswitches are 4¾ in. long, 2¾ in. wide, ⅞ in. high, and weigh only 1 lb. More than

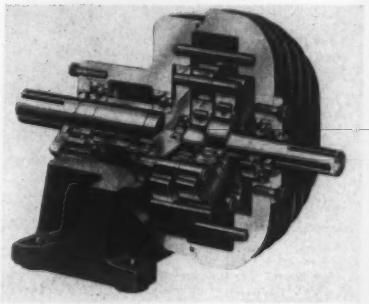
five different standard switch ratings and arrangements are available. Housing is cast iron with black wrinkle finish. **Vemaline Products Co.**, P. O. Box 222, Hawthorne, N. J. D

Circle 665 on Page 19

Reduction Drive

is cycloid-type unit

Hi-Range compact reduction drive, based upon cycloid principle of speed reduction, is 40 to 60 per cent smaller than other types of reducers with comparable ratings. Drive also provides wider range of torque than other types of reducers. Torque ranges from about 30 to over 80 lb-in. per pound of reducer weight.



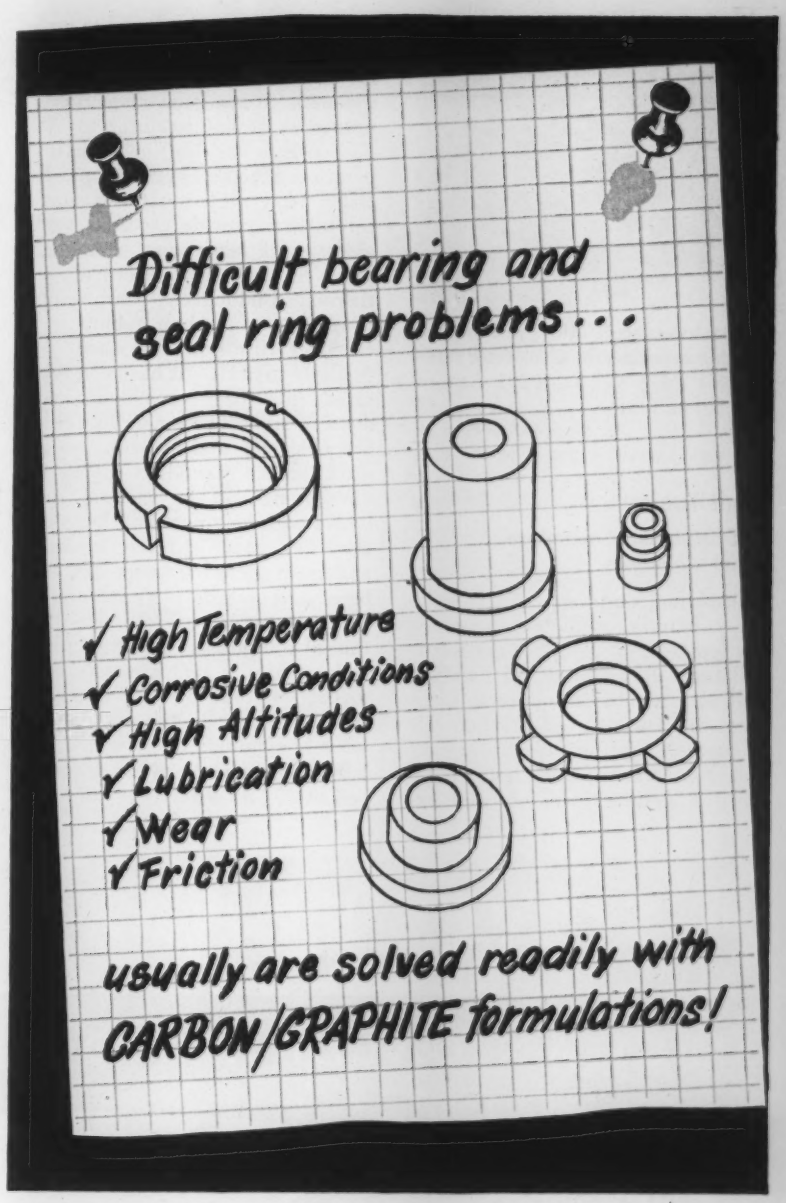
Drive provides wide selection of ratios, and runs virtually without noise in oil-sealed, cast-iron housing. Sizes vary from small units for instruments to drives for large machine tools. **Black Tool Co.**, 1924 S. Navajo St., Denver 23, Colo. K

Circle 666 on Page 19

Hydraulic Cylinders

have one-piece piston with solid head

Interchangeable, heavy-duty, high-pressure hydraulic cylinders are available for 2000 psi (3000 psi non-shock) operation. Twelve bore sizes range from 1⅛ through 12 in., available in 23 different mounting styles and four different rod ends for maximum flexibility of installation. One-piece piston with solid head eliminates air pockets and allows for quick bleeding. Heli-Coil inserts, used as piston lock, eliminate use of nuts, set screws, lock pins, and other means of locking piston on rod. Made of high-ten-

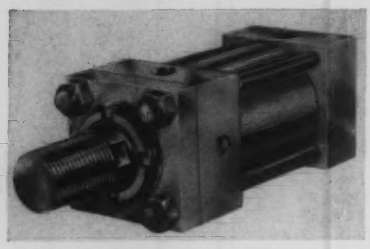


Many standard grades . . . countless specials . . . with physicals to match your performance requirements exactly. Outline your application for a prompt recommendation. STACKPOLE CARBON CO., St. Marys, Pa.

STACKPOLE

ROCKET NOZZLES • PUMP VANES • TURBINE RINGS • GRAPHITE CHEMICAL ANODES • VOLTAGE REGULATOR DISCS • BRUSHES FOR ALL ROTATING ELECTRICAL EQUIPMENT • WELDING & BRAZING TIPS • ELECTRICAL CONTACTS • CERAMIC MAGNETS • FERROMAGNETIC CORES • FIXED & VARIABLE COMPOSITION RESISTORS . . . and many other carbon, graphite and electronic products.

Circle 524 on Page 19



sile, stainless-steel alloy, piston lock resists corrosion and gives long service. **S-P Mfg. Corp.**, 30201 Aurora Rd., Solon, Ohio. G

Circle 667 on Page 19

Small Tubing

of columbium, tantalum, and vanadium

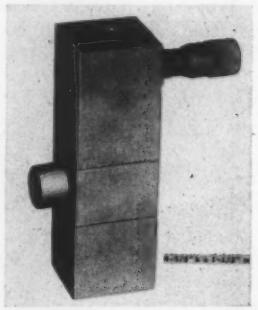
Columbium, tantalum, and vanadium tubing is available in seamless grade and in fully annealed, half hard drawn, and full hard, as well as intermediate tempers. Sizes range from 0.012 to 1.125 in. OD. Moderately low neutron absorption makes columbium highly suitable for fuel element cladding, and excellent corrosion resistance to water, liquid metals, and molten salts makes it useful for piping for reactor coolants. It has good stress rupture properties at temperatures to 2000 F, hence is suitable for high temperature structural applications. Extremely low work-hardening rates of columbium provide excellent workability and fabrication characteristics. It has low electrical and thermal conductivity. Outstanding property of tantalum tubing is its excellent corrosion resistance, particularly to acids. It has been fabricated into heat exchangers, condensers, and coils for handling chlorine, chlorides, and hydrochloric and nitric acids. Tantalum tubing has also been used in vacuum tubes where high melting point, low vapor pressure, good electron emission, and good gettering properties have been advantageous. Vanadium has a density approximately two-thirds that of columbium, and strength-to-weight ratio is approximately equal to that of Type 304 stainless steel. It is extremely ductile and has low work-hardening rate with good fabrication characteristics. Electrical resistivity exceeds that of most metals, and it has good corrosion resistance to almost all acids and alkalies. **Superior Tube Co.**, 1578 Germantown Ave., Norristown, Pa. E

Circle 668 on Page 19

Constant-Volume Regulator

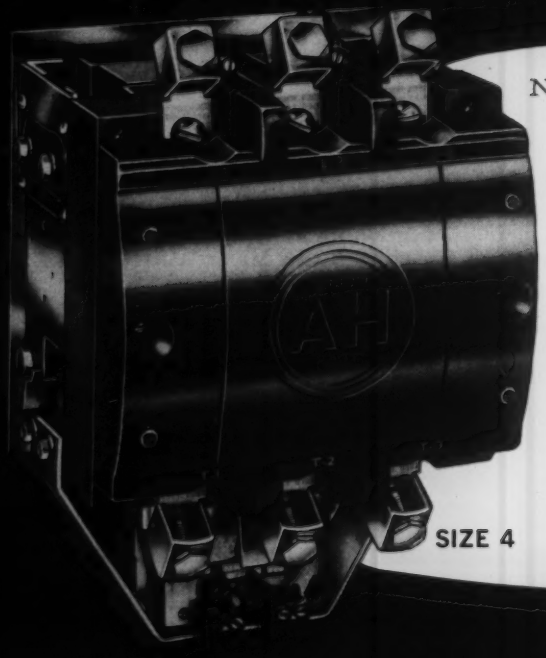
has output volume of 5 to 180 scfh

Constant-volume regulator provides fully automatic regulation for control applications where constant-volume output of gas or air is necessary regardless of fluctuating pressure drop. Capacity is controlled by micrometer adjustment to assure ac-



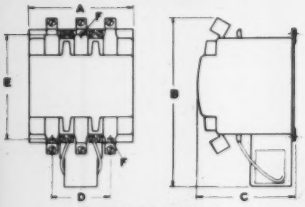
ARROW AH HART

MECHANICALLY HELD CONTACTORS



SIZE 4

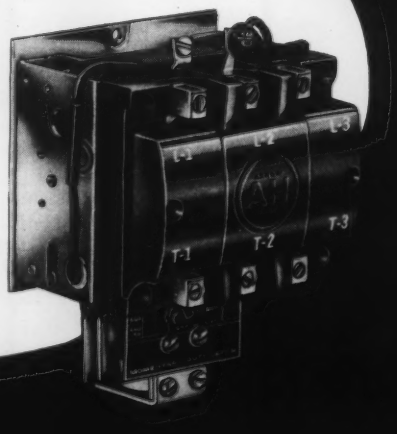
NEMA SIZES 0 through 5



DIMENSIONS

SIZE 4	SIZE 1
A—7½	A—3½
B—12½	B—5¾
C—7	C—3¼
D—4	D—2
E—7½	E—3¼
F—$^{21}/_{64}$	F—$^{11}/_{64}$

SIZE 1



curacy of desired output. Output volume is from 5 to 180 scfh at pressure differentials from 1 to 25 psi. Regulator has brass body. **George W. Dahl Co. Inc.**, 86 Tupelo St., Bristol, R. I. B

Circle 669 on Page 19

Fastener Seals

are now available in stainless steel

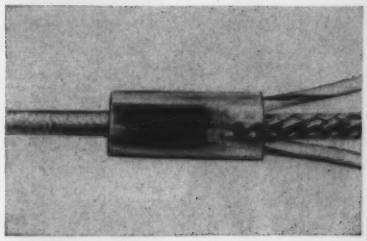
Sealing devices for bolts, studs, and other fasteners and fittings, formerly available only in steel and nonferrous metals, are now available also in stainless steel. Stat-O-Seals are furnished in all standard sizes except −6 and −8, for noncorrosive applications. **Parker Seal Co., Div., Parker-Hannifin Corp.**, 10567 Jefferson Blvd., Culver City, Calif. L

Circle 670 on Page 19

Shielded-Wire Ferrule

incorporates matching post-insulation sleeve

Termashield shielded-wire ferrule incorporates an insulation sleeve



which slips on and snaps in place over previously crimped ferrule. Slipping insulation on after crimping prevents interference of sleeve with insertion of ground tap leads. It also permits maximum visibility during insertion process. Ferrule and matching post-insulation sleeve are color coded. **AMP Inc.**, Eisenhower Boulevard, Harrisburg, Pa. E

Circle 671 on Page 19

Aluminum Wire

for 1000-F temperature

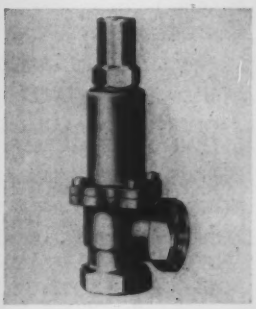
Boron-free aluminum wire is available in sizes from 4 to 100 mils. Suited for high-temperature (1000 F) and nuclear radiation environments, wire is insulated with Durock boron-free ceramic. Coating is 0.00035 to 0.001 in. thick, depending on gage of wire. Ceramic is nonhygroscopic, has excellent abrasion resistance and high tensile strength. **Technical Industries Corp.**, 389 N. Fair Oaks Ave., Pasadena, Calif. L

Circle 672 on Page 19

Back-Pressure Valves

with relief-pressure range from 5 to 600 psi

Two back-pressure valves for use on tool-lubrication machines, diesel-engine lubrication, oil-burner feeds,



MOTOR CONTROLS

ONE/HALF

THE SIZE AND WEIGHT of CONVENTIONAL CONTROLS! WITH ADVANTAGES ONLY "RA" DESIGN CAN OFFER

Arrow-Hart now offers Mechanically Held Contactors with or without coil clearing contacts, in NEMA Sizes 0–5, as well as its complete line of "Right Angle" design contactors. Applications include machine tool control circuits and electric furnaces requiring continuity of operating sequence despite voltage failure or interruption. Also widely used in locations where quiet is essential and where the hum characteristic of a-c magnets in an electrical holding circuit is objectionable.

MECHANICALLY HELD OR STANDARD CONTACTORS OFFER:

- Small Size
- Straight-thru Front Wiring
- Improved Performance & Dependability
- Greater Magnet Efficiency . . . control transformers up to ⅓ smaller
- Easy to Add Auxiliary Interlocks
- Less Weight
- Easy Inspection, Installation, Maintenance
- Vertical Contacts . . . prevent accumulation of breakdown materials
- Pressure Lugs Sizes 1 thru 5
- Hard Epoxy Coils

Write today for details to The Arrow-Hart & Hegeman Electric Company, Dept. MD, 103 Hawthorn St., Hartford 6, Connecticut

ARROW-HART of HARTFORD

Quality since 1890

MOTOR CONTROLS • ENCLOSED SWITCHES • APPLIANCE SWITCHES • WIRING DEVICES

Circle 526 on Page 19

42

Complete reprints of major articles now available from MACHINE DESIGN

USE THIS FORM TO ORDER YOUR COPIES TODAY!

Number Copies		Price Per Copy
_____	ELECTRIC MOTORS	$1.00
_____	ELECTRONIC AND ELECTRIC POWER SUPPLIES	1.00
_____	FRICTION-CLUTCH TRANSMISSIONS	1.00
_____	HUMAN-FACTORS ENGINEERING	1.00
_____	DIRECTORY OF MATERIALS—18th Edition	1.00
_____	PRODUCTION CHARACTERISTICS OF ENGINEERING METALS	1.00
_____	DESIGN MANUAL ON ADHESIVES	1.00
_____	NONMETALLIC GASKETS	1.00
_____	ADJUSTABLE SPEED DRIVES (Electrical, Mechanical, Hydraulic)	2.00
_____	ADJUSTABLE-SPEED ELECTRIC-MOTOR DRIVES	1.00
_____	SPEED REDUCERS AND GEARMOTORS	1.00
_____	INTERNAL COMBUSTION ENGINES	1.00
_____	DESIGN FOR FATIGUE LOADING	1.00
_____	WHY MACHINE PARTS FAIL	1.00
_____	STRESS ANALYSIS IN DESIGN	1.00
_____	DIMENSION CONTROL IN DESIGN	1.00
_____	HYDRAULIC SERVO FUNDAMENTALS Vol. I	1.00
_____	HYDRAULIC SERVO FUNDAMENTALS Vol. II	1.00
_____	HYDRAULIC SERVO FUNDAMENTALS Vol. III	1.00
_____	QUALITY CONTROL METHODS	1.00
_____	MULTIPLE CIRCUIT SWITCHES	1.00
_____	ELECTRICAL CONNECTORS	1.00

Number Copies		Price Per Copy
_____	TRANSACTIONS OF THE FIRST CONFERENCE ON MECHANISMS	1.00
_____	TRANSACTIONS OF THE SECOND CONFERENCE ON MECHANISMS	1.00
_____	TRANSACTIONS OF THE THIRD CONFERENCE ON MECHANISMS	1.00
_____	TRANSACTIONS OF THE FOURTH CONFERENCE ON MECHANISMS	2.00
_____	TRANSACTIONS OF THE FIFTH CONFERENCE ON MECHANISMS	3.00
_____	MECHANISMS FOR INTERMITTENT MOTION	1.00
_____	POLYDYNE CAM DESIGN	1.00
_____	EVALUATING ENGINEERS	1.00
_____	ENGINEERING MANAGEMENT	2.00
_____	MEN AND MACHINES	1.00
_____	DESIGNING WITH TEFLON	1.00
_____	DYNAMIC SEALS AND PACKINGS	1.00
_____	MECHANICS OF VEHICLES	2.00
_____	1956 DATA SHEETS	2.00
_____	1957 DATA SHEETS	2.00
_____	1958 DATA SHEETS	2.00
_____	TIPS AND TECHNIQUES—VOL. I (Drafting Aids)	1.00
_____	TIPS AND TECHNIQUES—VOL. II (Engineering Aids)	1.00
_____	PLANNING NEW PRODUCTS	3.00
_____	DESIGN GUIDE FLEXIBLE COUPLINGS	1.00

MACHINE DESIGN

Reader Service
Penton Building
Cleveland 13, Ohio

TOTAL COPIES_____ TOTAL ORDER $_____

Remittance or Company Purchase Order must be enclosed with order.

NAME_____ TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE_____ STATE_____

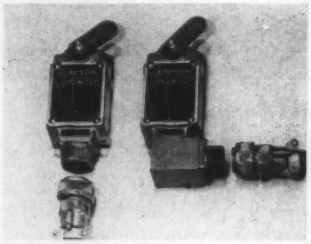
(Add 3% to orders in Ohio to cover State Sales Tax)

and oil-cooling units have all bronze bodies, stainless-steel springs and trim, and are totally enclosed. They are available in ½ to 1¼-in. sizes with female inlets and outlets. Relief pressure ranges from 5 to 600 psi with maximum temperature of 450 F. Type K-10 features balanced-piston design so that valves are virtually unaffected by pressures or pressure changes in outlet line. Type K-20 features an aspirating nozzle which allows valves to produce high capacities and close control of system pressures. **Cash-Acme**, P. O. Box 191, Decatur, Ill. I

Circle 673 on Page 19

Limit Switch

has sealed, plug-in electrical connection



Model PL100W limit switch incorporates completely sealed, plug-in electrical connection. Switch is furnished with male receptacle unit permanently mounted on and wired directly to switch. Receptacle unit is fully sealed internally and externally at switch entrance, and switch itself is completely gasketed and sealed at factory. Cord half of switch is a precision-built female plug and screw collar for quick attachment to switch with standard 4-ft length of machine-tool cable. Cable and plug are wired and epoxy sealed, and are also held together with strong mechanical clamp. **R. B. Denison Mfg. Co.**, 386 Broadway, Bedford, Ohio. F

Circle 674 on Page 19

Transistor Chopper

has self-contained drive transformer

Type 6025 transistor chopper has SPDT switching action for operation from 50 to 5000 cps. Drive can be 6.3 v, sine or square wave, with

Perfection Worm Gear Speed Reducers by American Stock Gear are available in 9 complete series with ratios ranging from 5 to 1 to 60 to 1 for input revolutions ranging from 300 per minute to 1800 per minute. Speed Reducers are furnished in horizontal right angle drive with worm in either top or bottom position and are also furnished in vertical right angle drive. Integral worm and shaft is made of selected quality, case hardened alloy steel. Threads are precision ground and accurately mated with worm gear. Shafts are mounted in Timken anti-friction roller bearings. Heavy rigid cast-iron housings . . . easily accessible oil filling level and drain plugs are provided for oil reservoir. Oil seals are of selected cirvis leather which assures maximum sealing effect. Available through your nearest American Stock Gear Distributor.

Write for new 16 page catalog covering the complete PERFECTION Speed Reducer line.

AMERICAN STOCK GEAR DIVISION
PERFECTION GEAR COMPANY • HARVEY, ILLINOIS, U.S.A.

Circle 528 on Page 19

RBC

Heavy duty

SELF-ALIGNING BUSHING ASSEMBLIES

. . . for industrial and aircraft applications where misalignment tends to exist with high static loads or intermittent oscillation under load.

LONGER LIFE of the RBC Self-Aligning Bushing is the result of precision ground and hardened (60-63 Rockwell C.) bearing surfaces on both the outer race and the ball. Axial fracture of the outer race after it is precision ground and hardened permits insertion of the ball, eliminates dirt and grit collecting pockets, provides more efficient lubrication control. Recessed snap ring maintains integral unit for ease of assembly. RBC Self-Aligning Bushings are made of SAE 52100 steel and coated with molybdenum disulphide.

• For help in removing the "MIS" from your "MISalignment" problems consult the RBC Engineering Department or . . .

Write for Bulletin SF-86.

AD 1158

ROLLER BEARING COMPANY OF AMERICA
Sullivan Way, West Trenton, N.J.

Circle 529 on Page 19

power requirement less than 20 mw, or as high as 14 v at frequencies above 100 cps. Switching is performed without moving parts, permitting unit to operate normally during shock and vibration. Output is linear within 2 per cent over range of signals from about ten times noise level to 100 v with signal current that does not exceed 10 ma. Unit, with drive transformer, is contained in a miniature metal case, is epoxy potted, and has seven-pin header. **Cambridge Div., Airpax Electronics Inc.**, Cambridge, Md. C

Circle 675 on Page 19

Cold-Bending Sheet

of magnesium coil stock

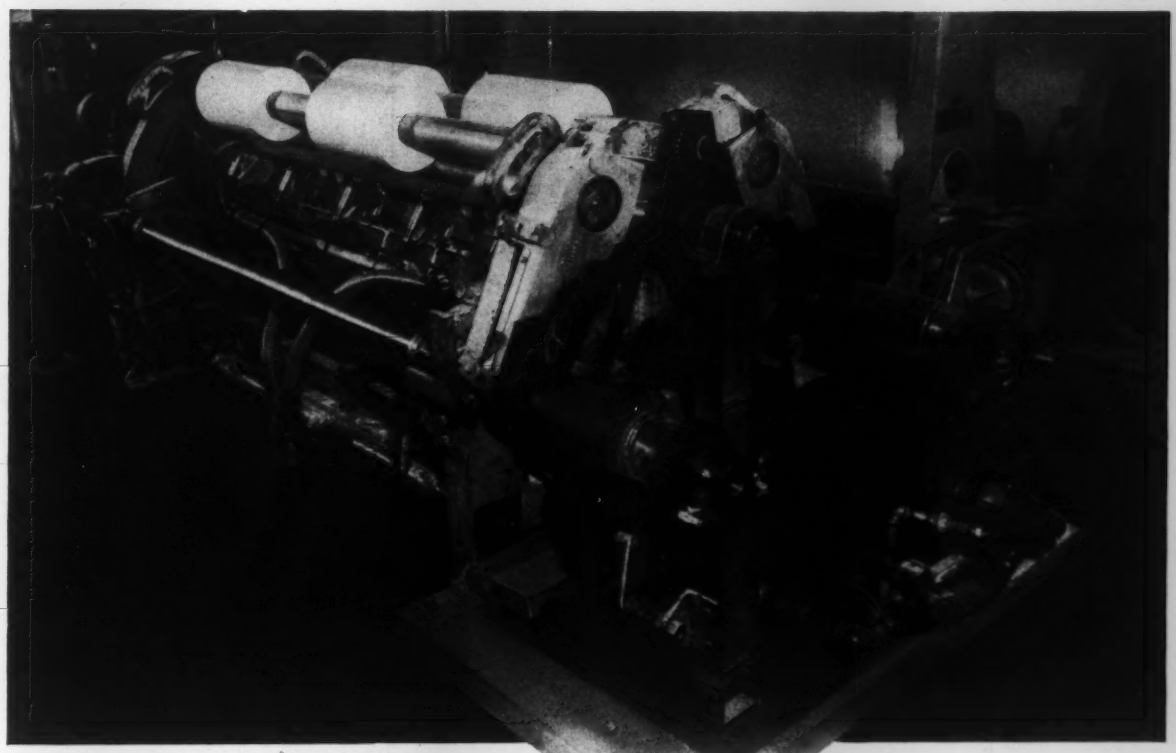
Magnesium sheet is for applications requiring good cold-bending characteristics at room temperature. Critical bends can be formed cold easily, eliminating in many cases need for heated dies. Material can be bent without cracking at room temperature through 90-deg angle around a mandrel radius equal to bend factor times nominal sheet thickness. Bends can be made either parallel or perpendicular to direction of rolling. Sheet is produced from coils of AZ31B-O alloy. It has lower tensile yield strength than standard AZ31B-O sheet, but meets requirements of federal specification QQ-M-44. **Dow Chemical Co.**, Midland, Mich. T

Circle 676 on Page 19

Silicon Power Rectifier

in 11/16-in. configuration

Ceramic-base silicon power rectifier is available with ratings to 20 amp at 150 C case temperature in an 11/16-in. hex-base configuration. Ceramic-base units eliminate need for insulating hardware and reverse-polarity units. Stud-mounted rectifiers have an alumina ceramic disc



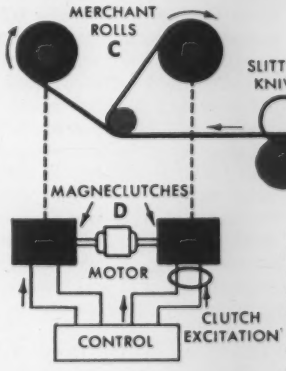
How the VICKERS® MAGNECLUTCH® CONTROLS TENSION...PREVENTS BREAKDOWN on this high-speed paper slitting machine

The smooth, trouble-free operation of this slitting machine of a well-known paper converter demonstrates another practical use of the Vickers Magneclutch, the dry magnetic particle clutch.

Two water-cooled, 200 lb-ft, 6-2-6 Magneclutches maintain uniform tension on the fast-moving web as it is unwound, slit and rewound. Strain, breaking or snarling of the paper is eliminated, downtime is prevented.

The Magneclutch is designed to provide precise regulation and transmission of torque, without grab or chatter. Torque responds quickly, is unaffected by temperature or humidity; water-cooled design dissipates slip heat rapidly; and since there is no wear on torque transmitting surfaces, service life is extremely long. Torque transmission, regulated by energizing current only, is independent of speed, and is easily and remotely controlled.

Write for Descriptive Bulletin on The Vickers Magneclutch



Paper is pulled from parent roll A, fed through slitting knives B, and rewound on merchant rolls C. As the merchant roll diameters increase, additional windup torque needed is provided by increased electrical excitation of the Magneclutches D. Clutches slip to maintain constant web speed and tension.

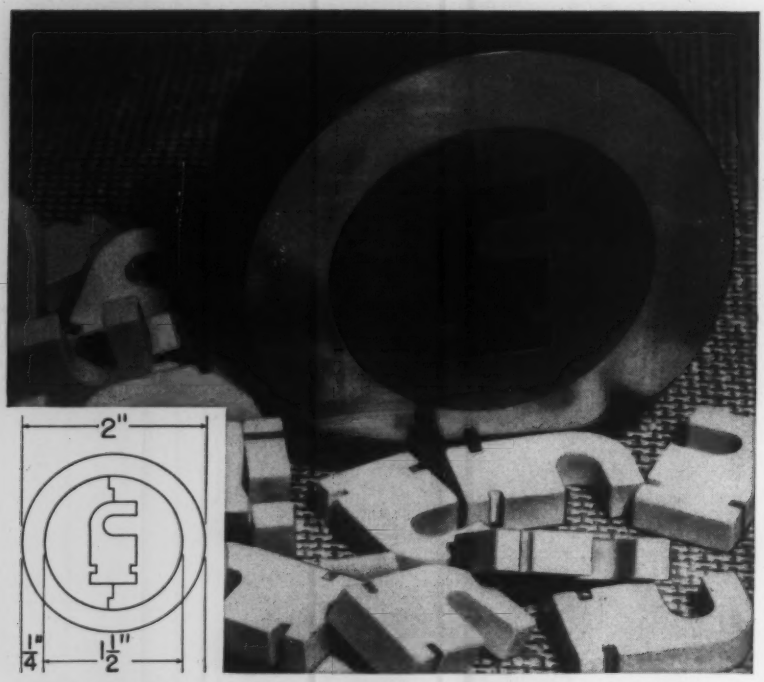
ELECTRIC PRODUCTS DIVISION — VICKERS

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION

EPA 6100-2

ELECTRIC PRODUCTS DIVISION
1881 LOCUST STREET • SAINT LOUIS 3, MISSOURI

Sales Engineering Offices
ST. LOUIS—CEntral 1-5830 · CHICAGO—JUniper 8-2125 · CLEVELAND—EDison 3-1355
DETROIT—KEnwood 4-8070 · NEW YORK—LEnnox 9-1515 · LOS ANGELES—DAvenport 6-8550
WASHINGTON, D. C.—EXecutive 3-2650 · BOSTON (Representative)—CEdar 5-6815
DALLAS (Representative)—EMerson 8-4655



Section of die used for making a ceramic component for the electrical appliance industry. One half of the dark center portion subjected to wear is made from Kennametal grade K96 . . . the other half from an "equivalent" competitive carbide.

By accident . . . this company found

There is a difference in CARBIDES

An accident that broke one section of this die gave Du-Co Ceramics Company, Saxonburg, Pa., an excellent opportunity to compare carbides. The original die was made from Kennametal grade K96 and had turned out 800,000 steatite hooks before the accident. In replacing the broken section, an "equivalent" competitive carbide was selected.

After an additional run of 200,000 hooks, the original K96 section of the die still showed no sign of undercutting from abrasion. A dull finish was the only evidence of wear . . . after 1,000,000 pieces.

The newer section, however, showed definite undercutting after 200,000 and Du-Co estimates a total of 500,000 will be its maximum life.

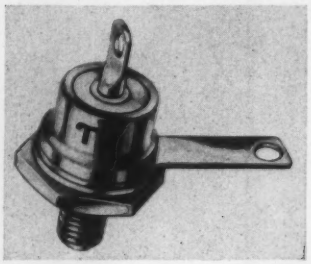
Chances are an answer to *your* wear or corrosion problems can be found within the wide range of Kennametal compositions. Hammers for grinding and pulverizing machines, rolls for cold rolling other metals, gripping devices that bite into the hardest steel, pump seals for highly corrosive acids, valve parts that resist attacks by acid and abrasive slurries . . . these are but a few of the many successful applications of Kennametal compositions.

And further advances are still being made. Recently developed Grades K601 and K701, for example, offer new economies in resistance to corrosion. For applications requiring strength at extremely high temperatures (to 2200°F), the Kentanium* series of hard titanium carbide alloys is unmatched.

For more details contact your Kennametal Representative or write KENNAMETAL INC., Department MD, Latrobe, Pennsylvania. 97238

*Trademark

INDUSTRY AND
KENNAMETAL
...Partners in Progress



mounted between top-hat assembly and hex base, electrically insulating mounting base from rectifying junction. Disc is of low thermal resistance and high electrical insulation. **Transitron Electronic Corp.**, 168 Albion St., Wakefield, Mass. B

Circle 677 on Page 19

Back-Pressure Regulator

controls 50-6600 lb of steam per hr

No. 1165 ductile iron or No. 1265 bronze back-pressure regulator is available in ½ to 2-in. sizes. It is suitable for pressures to 250 psi wsp and temperature to 500 F. Regulator is used in industry whenever accurate control, tight shut-off, and minimum maintenance are required. Regulator easily controls 50-6600 lb of steam per hr or 7-190 gpm of water. Sliding gate seats slice across flow to give balanced action. Seats are also self-cleaning and self-lapping to insure tight shut-off during life of regulator. **OPW-Jordan**, 6013 Wiehe Rd., Cincinnati 13, Ohio. G

Circle 678 on Page 19

Spool Valve

for unlimited industrial applications

Features of spool valve include interchangeability of all operators on both ends of body, availability of various types of neutral position spools, and reduction of spare parts inventory. Standard operators include single and double solenoid, hand, pedal, treadle, cam, bleeder, and remote air. There is no spool wear, since spool contacts only seals, and seals are not subject to extrusion or cutting. Valve has unlimited industrial applications. **Automatic Valve Co.**, 37415 Grand River, Farmington, Mich. T

Circle 679 on Page 19

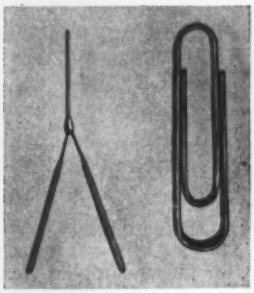
ENGINEERING DEPARTMENT

EQUIPMENT

Strain Gage

fits inside components or in tight spots

Mono-Filament strain gage consists of a single, straight, strain-sensitive element, with suitable leads attached, and coated with electrically insulating cement. Total diameter is less than 0.012 in. Coating permits use, in application, of non-insulating cements and cements which cure at low temperatures. Unit has many applications in tight



spots and inside components. It fits easily into narrow sections such as ligaments in tube sheets and headers, small tubes, rods, spokes, wires, and gear teeth. Configuration permits use in honeycomb and corrugated structures. Gage is furnished in various materials, configurations, and electrical resistances for different purposes. It withstands temperatures to 2000 F with use of proper insulating cements. **High Temperature Instruments Corp.**, Bala-Cynwyd, Pa. E

Circle 680 on Page 19

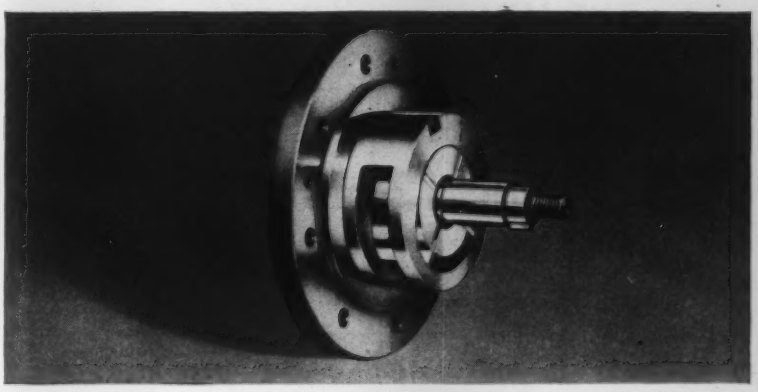
Recording Thermometer

portable unit uses dry stylus

Low-Cost recording thermometer can be used as a highly portable field-service unit for recording time and temperature. It can also be used for permanent or temporary mounting, records in any position, and can be encased in a thin poly-

Harbormaster marine power package from Murray & Tregurtha, Inc., Quincy, Mass., installs fast — provides rugged power, 360° maneuverability for many craft.

How "Harbormaster" designers capitalize on automatic reversing feature of Brown & Sharpe pumps



Brown & Sharpe Special No. 8103 Pump

Problem: Designers of this heavy-duty marine power package want a dependable self-priming, positive displacement pump in the bottom of the outboard propulsion column to provide a fountain of lube oil to bearings and gears at the top of the column. The pump has to maintain unidirectional delivery, regardless of direction of shaft rotation (propeller in forward or reverse) — in any position (horizontal to vertical) — at variable speeds of 96 to 410 rpm. It must also be economical, and long-lasting.

Solution: Brown & Sharpe's Special No. 8103 Automatic Reversing Vane Pump, suggested by the local B&S engineer-representative, is now built into each Harbormaster. It uses ports provided in the casting.

Idea: For the best solution to any pump problem — Contact Hydraulics Division, Brown & Sharpe Mfg. Co., Providence 1, R. I. — or your B&S engineer-representative. Brown & Sharpe makes gear, vane and centrifugal pumps to handle more fluids than any other manufacturer.

Brown & Sharpe
PRECISION CENTER

Circle 532 on Page 19

ROCKFORD

ROCKFORD CLUTCHES WITHSTAND THE MOST SEVERE SERVICE

Severe Service is possible only through specialized equipment and highly practiced skills—the same as lie behind the quality of every ROCKFORD CLUTCH. Each order is given the extra measure of care that makes ROCKFORD CLUTCH quality a byword in industry. Due to rigidly held specifications covering the chemical analysis of materials, and properly governed heat treatment, the pressure plates used in ROCKFORD CLUTCHES withstand the most Severe Service. The plates are made from superior quality materials of more than adequate tensile strength. Heat treatment further improves the grain-structure and strength of the iron. We urge your engineers to consider this and other advantages of ROCKFORD CLUTCHES—when designing your next application of a clutch.

Small Spring Loaded

Automotive Spring Loaded

Heavy Duty Spring Loaded

Oil or Dry Multiple Disc

Heavy Duty Over Center

Light Over Center

Power Take-Offs

Speed Reducers

SEND FOR THIS HANDY BULLETIN

Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

ROCKFORD Clutch Division BORG-WARNER

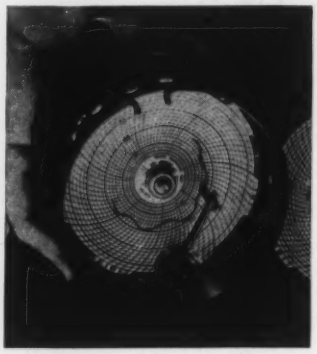
311 Catherine St., Rockford, Ill., U.S.A.

Export Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

ROCKFORD B-W BORG-WARNER

CLUTCHES

ethylene bag to record temperatures of liquids or wet environments. Thermometer uses a dry scriber and spring-wound clock movement. It is available in two different temperature ranges, 20 to 220 F or −40 to +160 F. Different time ranges available are 24 hr or 7 day. Unit



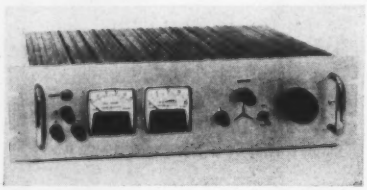
is 3 15/16 in. in diam, 2⅞ in. high, and weighs 14 oz. **Pacific Transducer Corp.**, 11836 W. Pico Blvd., Los Angeles 64, Calif. L

Circle 681 on Page 19

Power Supplies

are transistorized, rack-mounted units

Series 36 power supplies, featuring automatic protection system, furnish 0-36 v variable dc output at 1.5, 2.5, 5, 10, or 15 amp with 0.01 per cent load regulation and 0.05 per cent line regulation. Supplies are packaged for 19-in. rack mounting with panel heights from 3½ for 2.5-amp unit to 7 in. for 15-amp supply. Remote programming is available in all current ranges. Regulator circuit allows

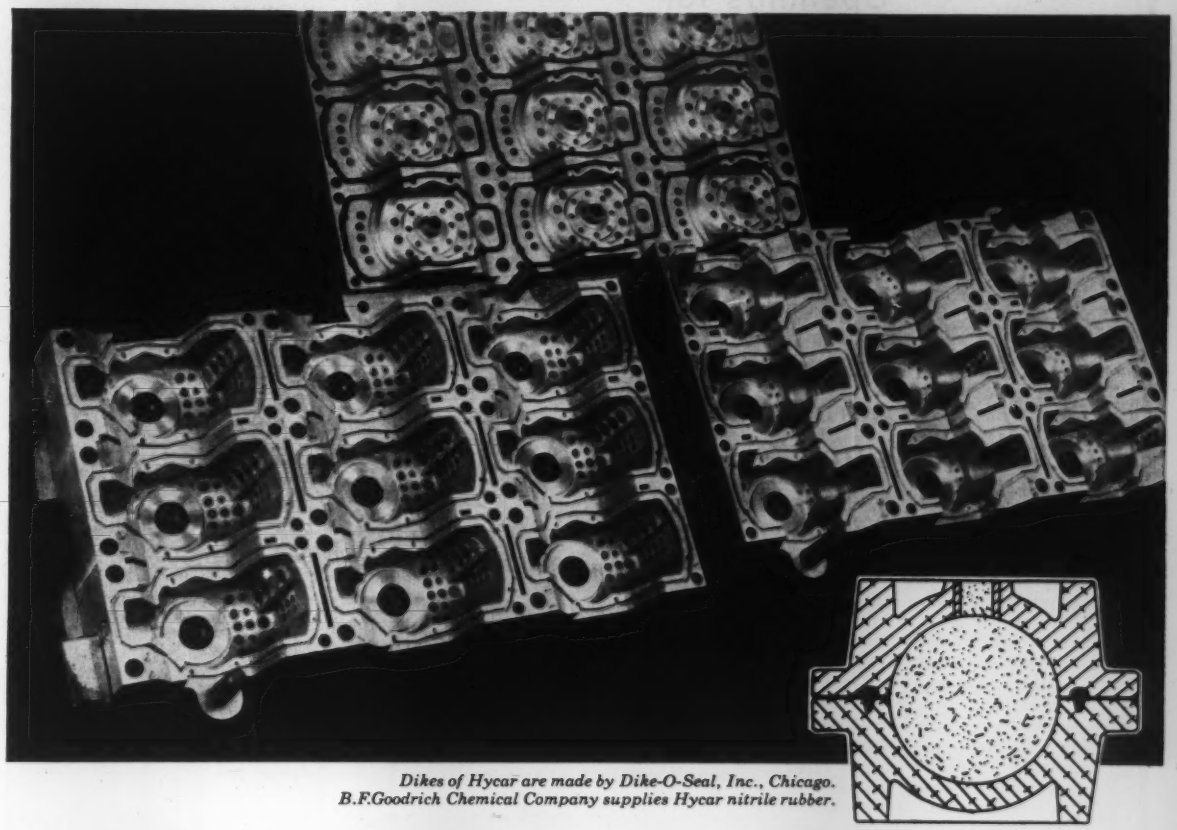


transistors to operate at lower temperature for higher reliability. For the 1.5-amp dual and 2.5-amp supply, only convection cooling is required. Forced-air cooling is employed for higher current ratings. **Trygon Electronics Inc.**, Pleasant Ave., Roosevelt, L. I., N. Y. D

Circle 682 on Page 19

Another new development using

B.F.Goodrich Chemical *raw materials*



Dikes of Hycar are made by Dike-O-Seal, Inc., Chicago.
B.F.Goodrich Chemical Company supplies Hycar nitrile rubber.

Hycar seals go to core of pressing foundry problem

Modern foundry practice calls for cutting costs by blowing sand into core boxes under pressure. The result is a better core and eventually a better casting—but there are problems. Without a perfect seal, operators get a condition called "blow-by", an erosion of core boxes that may result in flaws in the finished casting—as well as damaging the box itself.

The problem is being solved with flexible Dikes made from Hycar nitrile rubber. These Dikes provide a perfect seal under some tough operating conditions. The Dikes have to be flexible to fit the outlines of complicated core box parting faces. And they stay in place during core box cleaning, exposing them to live steam, alkali or even fuel oil.

Since Hycar retains its resilience under a wide range of temperature and the most severe mechanical deformation, it proved ideal. In addition, it has unusual abrasion resistance and can withstand hydrocarbons and chemicals that destroy ordinary rubber. Hycar may be the material that can help you get more results for your product. For information, write Dept. CM-6, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

Hycar
REG. U. S. PAT. OFF.
Rubber and Latex

B.F.Goodrich Chemical Company
a division of The B.F.Goodrich Company

B.F.Goodrich GEON polyvinyl materials • HYCAR rubber and latex • GOOD-RITE chemicals and plasticizers

Openings for

DESIGN ENGINEERS

for

GAS TURBINE ENGINES

in Solar's rapidly expanding gas turbine programs in sunny San Diego

Solar has immediate openings for Preliminary Design and Product Design Engineers in its fast-moving gas turbine programs. Several new contracts have been received for industrial, non-military applications, as well as certain new military turbine development jobs. This growing diversification has created expanding challenges and opportunities. Solar is a world leader in small gas turbines, having pioneered in their design and development since 1945. The company has built and sold more than 2500 gas turbines. Join in this exciting work now for a brilliant future.

QUALIFICATIONS

B.S. in Engineering preferred, plus at least three years experience in gas turbine design. U.S. citizenship not required for some of the positions open.

SOLAR SPECIFICS

Solar is a medium-sized company (2500 people) that has been in the mechanical and aeronautical engineering fields since 1927. It is big enough to offer the most advanced personnel policies, yet small enough so you don't get lost in the crowd. Salary and performance reviewed semi-annually. Liberal relocation allowances. The special professional status of engineers is appreciated and recognized. A new 60,000 sq. ft. engineering building, necessitated by expanding research and development, will be completed soon on the edge of San Diego Bay.

SEND RESUME

Please send resume of your qualifications to Louis Klein, Dept. **E-444,** Solar Aircraft Company, 2200 Pacific Highway, San Diego 12, California.

SOLAR AIRCRAFT COMPANY

LIVE BETTER, TOO! In addition to greater opportunities for personal achievement, Solar offers you the chance to live better in sunny San Diego. This famous resort area has the finest year-around climate in America. Cultural, recreational and educational facilities are excellent. You and your family will enjoy life more at Solar in San Diego.

THE ENGINEER'S Library

Recent Books

Practical Design Guide. *By R. A. Rinchuls; 132 pages, 8½ by 11 in., paperbound; published by Pelex Publishers Inc., 95 Liberty St., New York 6, N. Y.; available from Stephen Howard, 225 Stone Ave., Brooklyn 33, N. Y.; $3.50 per copy.*

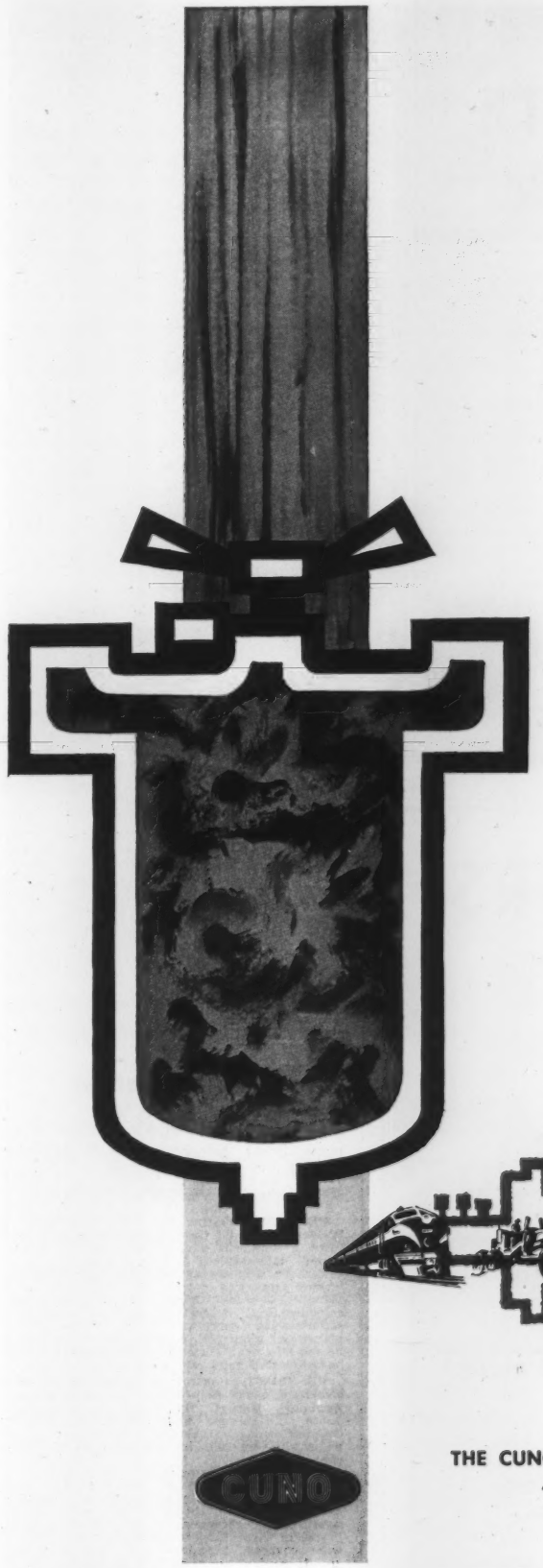
This revised guide presents practical ideas for designing or revising labor-saving production equipment. Discussed under pneumatics are commercial valves, air-valve operation and use, and air circuits. Data for motors, drives, and special applications are included in the treatment of electrical circuits. Actual production examples are given for indexing methods and special feed devices for automatic machinery. Also covered are types of cams, cam motion, and formulas for cam calculations. Drawings and charts help illustrate the devices used and recommended.

Analysis of Straight-Line Data. *By Forman S. Acton, associate professor of electrical engineering, Princeton University; 267 pages, 5¾ by 9 in., clothbound; published by John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from* MACHINE DESIGN, *$9.00 per copy postpaid.*

Techniques that can be used to fit a straight line to experimental data are presented in this reference book. The methods are designed to help the experimenter analyze his data without the help of a statistician. Although some of the methods are not backed by published theories, they are discussed because they have been found useful. Each subject is introduced with data obtained for an actual experiment.

Manufacturers' Publications

Silicon Zener Diode Handbook. *126 pages, 5½ by 8½ in., paper cover, plastic-ring binding; available from Dept. ZDH, Motorola Inc., Semiconductor Products*

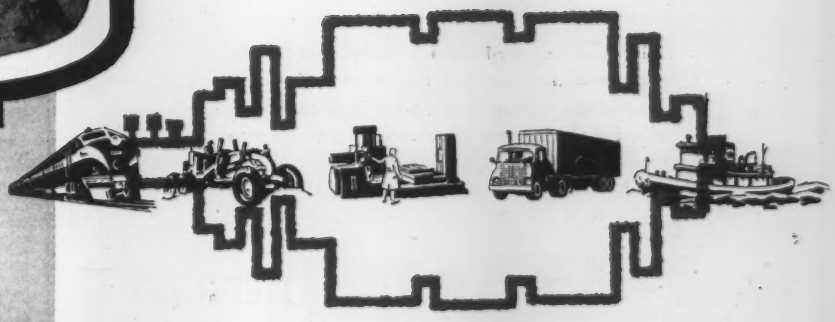


whatever the **power production application...** you can depend on **CUNO** engineered filtration

"The more complete the filtration, the more efficient the production of power." Cuno filters remove damaging contaminates and reduce costly stoppages.

To meet the specific requirements of *your* power production application, Cuno provides effective, engineered filtration with . . . Auto-Klean Self-Cleaning Edge-Type, Flo-Klean Automatic Self-Cleaning Wire Wound, Micro-Klean Disposable Depth Cartridge . . . available in a variety of housings.

Let us apply over 30 years of filtration know-how to *your* requirements.



THE CUNO ENGINEERING CORP., DEPT. 12, MERIDEN, CONN.

A Leader in Industrial Filtration for More Than 30 Years

Sales Offices throughout the United States and Canada
In Canada write: Peacock Bros., Ltd., P.O. Box 1040, Montreal 3, P.Q.

Circle 536 on Page 19

*A New Concept in Pumping *Abrasive Liquids!*

VIKING PUMPS WITH CERAMIC BEARINGS AND MECHANICAL SEALS

After years of experimenting and testing, Viking has developed this new pump that assures you double to triple life, while pumping paints, inks and other *abrasive liquids. Among its features are special ceramic bearings and mechanical seals. Designed for heavy duty, these pumps handle liquids from a minimum viscosity of 100 S.S.U. to heaviest viscous types.

G.P.M. SIZES 3 - 6 - 12 - 16 - 25 - 40

When writing for information, please give:

- Liquid to be pumped
- Viscosity of liquid (S.S.U.)
- Percentage and type of solids present in liquid
- Temperature of liquid
- Specific gravity
- Capacity of pump
- Suction lift or head
- Discharge pressure

And ask for bulletin SP-507H

VIKING PUMP CO.

Cedar Falls, Iowa, U.S.A.

In Canada, it's "ROTO-KING" Pumps

See Our Catalog in Sweet's Product Design File

*Consult factory for recommendations for pumping abrasive liquids other than paints and inks.

Circle 537 on Page 19

HUMAN-FACTORS ENGINEERING

by John D. Vandenberg and C. Thomas Goldsmith

Thirty-one pages of helpful information for the designer contending with human limitations and capabilities. Special emphasis is given to design for vision, hearing, muscular performance and body dimensions in relationship to man-machine efficiency **$1.00 per copy**

A MACHINE DESIGN REPRINT

ORDER FROM: Machine Design Reader Service

Penton Building, Cleveland 13, Ohio

(Remittance or Company Purchase Order must be enclosed with order)

Div., 5005 E. McDowell Rd., Phoenix, Ariz.; $1.00 per copy.

Basic theory and design characteristics and considerations for voltage-limiting zener diodes are covered in this manual. Examples of zener-diode application in regulated power supplies and ac and dc amplifiers are presented. Other uses are described for surge protection, temperature compensation, and impedance cancellation. Several new and unusual approaches to circuit application illustrate different zener-diode characteristics. Specifications and test methods are described. Schematic drawings, tables, and curves are based on circuits actually designed and tested.

Fractional-Horsepower Motor Handbook. *66 pages, 6 by 9 in., paper covered, wire-ring binding; published by and available from Bodine Electric Co., 2500 W. Bradley Place, Chicago 18, Ill.; $1.00 per copy.*

This handbook is intended to help the designer select and match the small motor to his application. Motor classes, enclosure types, and terms are defined. Application fundamentals cover performance characteristics, wiring, speed control, reversing, and temperature rise. Other factors discussed are economics of motor purchase, installation, and operation and suggestions for care and servicing. Formulas, charts, and tables useful in motor application work are included.

Government Publications

OTS Technical Reports. Copies of reports listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

PB 151630. Testing for Notch Sensitivity in Welded Joints. By Carl E. Hartbower of Watertown Arsenal; 24 pages, 8 by 10½ in., paperbound, side-stapled; $0.75 per copy.

Various approaches to evaluating notch-bar impact properties of welded joints are reviewed. Reliable V-notch Charpy impact tests require consideration of method and of significant criterion of performance and definition of transition temperature. Test results can then be used to evaluate relative toughness of weld, heat-affected zone, and base metal.

PB 151802. Control of Variables in Heat Resistant Glass Reinforced Plastics, Volume 1, Summary Report. By Ralph H. Sonneborn, Allan B. Isham, and Frank W. Dennen, Owens-Corning Fiberglas Corporation; 62 pages, 8½ by 10¾ in., paperbound; $1.75 per copy.

Eight resin systems were investigated. Five types of fibrous-glass reinforcement were studied. Three fabric and yarn size removal systems were investigated, as well as the application techniques for five finishes. Laminates in three thicknesses from 0.05 to 0.4 in. were covered. Standard test, inspection, and quality-control methods are evaluated.

THOMSON TAKES EXTRA PAINS TO PREVENT FASTENING HEADACHES!
Statistical quality control procedures plus 100% inspection give double assurance of close adherence to specified rivet dimensions and positive protection against interrupted production.

YOU GET PRECISION FASTENING AT MASS PRODUCTION COSTS...

. . . when Thomson becomes your fastening partner.

In the Thomson line of more than 8,000 rivet designs, you'll find the semi-tubular, deep-drilled, bifurcated (split), shouldered or compression rivet that will give you the best strength-cost ratio in the fastening field. Produced to the industry's highest quality standards at production rates exceeding 20,000,000 rivets a day, these low-cost fasteners merit serious consideration in your product-improvement and cost-reduction programs.

Our leadership in solving fastening problems with quality rivets and precision rivet-setting machines since 1885 is at your service. What is your problem?

JTL

JUDSON L.

THOMSON

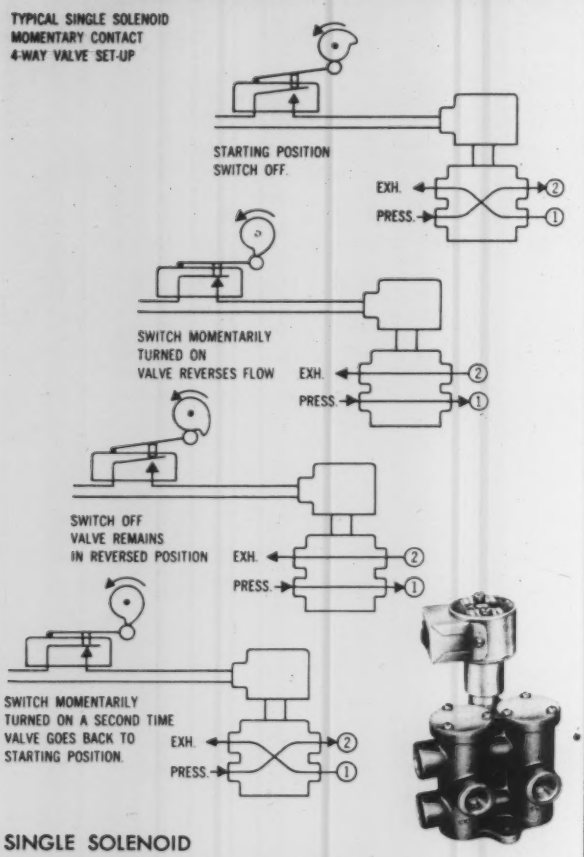
MFG. CO., WALTHAM 54, MASS.

Rivets and Rivet-Setting Machines

Offices: NEW YORK • ILLINOIS • INDIANA • OHIO • MICH. • PENN. • CALIF. • FLA. • TEXAS • MISSOURI • S. CAROLINA • ONTARIO, CAN.

New

MOMENTARY CONTACT SOLENOID AIR VALVES



SINGLE SOLENOID

Current is required only momentarily to change the position of the valve (two-position four-way and three-way valves). When the solenoid is energized the valve is actuated and remains in the actuated position after the current is off. On the next electrical impulse the valve is re-actuated (returned to its former position) and remains in that position with the power off.

DUAL SOLENOID

Dual solenoids prevent the valve from getting out of phase, particularly important in automated systems. If the same solenoid is energized twice in succession, the position of the valve will not be changed. The opposite solenoid must be energized to reverse the valve. Otherwise the operation is the same as described above for the single solenoid units.

Bulletin 590831 contains complete data.

CONTROL VALVE DIVISION

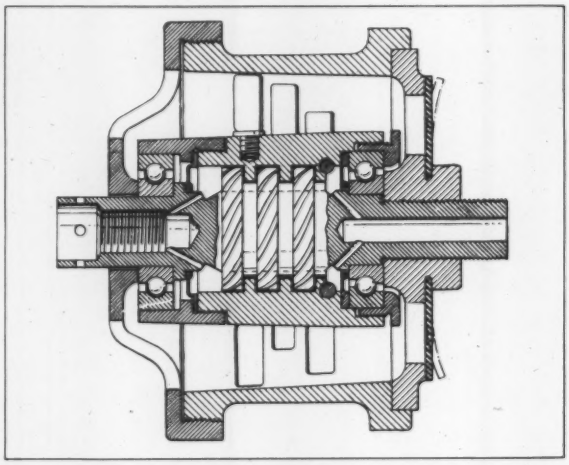
Barksdale valves

5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

NOTEWORTHY Patents

High-Pressure Reducing Valve

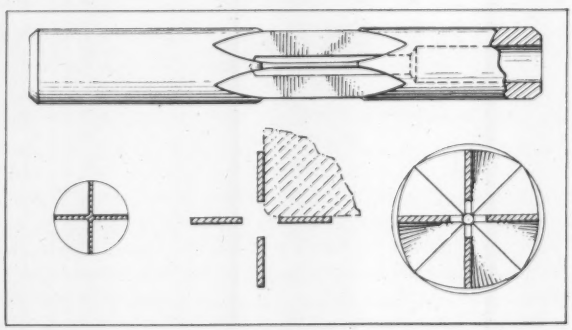
In a high-pressure gas-release valve, a rotor assembly, which performs useful work, moderates output which would form ice if released unchecked. Gas at vessel pressure drives a three-stage turbine which, in turn, drives



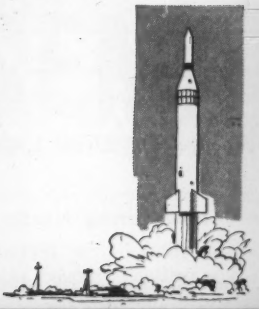
an impeller. The impeller forces air (or other environment gas) past a one-way flap valve into the same enclosure which receives the gas leaving the turbine. *Patent 2,906,447 assigned to Specialties Development Corp., Belleville, N. J., by Daniel Seed.*

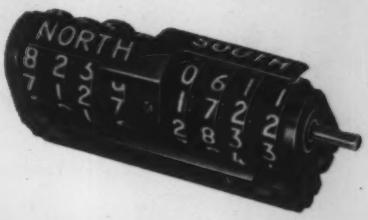
Torque-Sensitive Shaft

A length of a shaft is machined in a way to increase torsional deflection under load with minimum loss of



resistance to bending. Four 90-degree wedges of shaft material are removed to a depth less than one shaft radius. Remaining material forms a cross-shaped section. The center of the cross is removed by boring





Precision Readout Counters for navigational and control systems include Tandem counters (left), concentric drums, and multi-bank types. "Application Engineered" as complete packages.

PRECISION readout (DIGITAL IN-LINE) COUNTERS

High Speed Counter works at 1000 rpm with low torque and miniature size. For aircraft fuel-flow meter and similar applications.

New Concepts in Fast, Accurate Data Presentation

Precision Counter has completely internal supporting structure for instrument applications requiring extreme compactness, light weight and ruggedness. Three or five wheels, numerals in enamels or fluorescent paints.

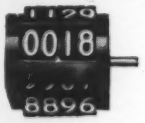
New 360° Tape-Type Bearing Counter recently developed for digital readout of angular relationship. Tape greatly reduces size and weight over conventional devices. "Application Engineered" as required.

Now you can use modern digital readout whenever extreme accuracy and precision indication are required. Veeder-Root Instrument-type Counters have "Application Engineered" tolerances, meet severe environmental specifications, operate accurately at high speeds, and offer wide selections of gearing and package designs.

Here are just a few of the ways Veeder-Root Precision Readout can improve and simplify product operation and performance . . .

- Figures and letters are positive, and easily comprehended
- In-line presentation more *quickly* read
- Replaces micrometer and vernier devices
- Maximum readability in miniature sizes
- Fractions, degrees are positively displayed

Take full advantage of digital readout with Veeder-Root Precision Counters — for military, aircraft, missile and industrial instrumentation. Standard types and special designs for all types of application, and design assistance is available from Veeder-Root Counting Engineers. Write or call.



High speed miniature counter suitable for applications requiring small size and weight, low torque and low cost. External pinion, ½" wheels, ⅛" characters.

Veeder-Root

HARTFORD 2, CONNECTICUT

"The Name that Counts"

New York • Chicago
Los Angeles • San Francisco
Seattle • St. Louis
Greenville, S. C. • Altoona, Pa.
Montreal
Offices and Agents in other principal cities

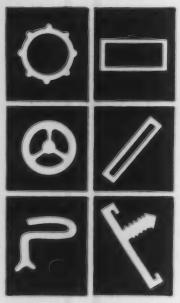
VRD-F9

for
Custom Plastics Extrusions
consult
YARDLEY

TUBING

Special shapes or standard, rigid or flexible, in diameters from ½" to 16". Our engineers have developed advanced techniques that can save time and money on the right shape for your specific needs.

SPECIAL SHAPES



We extrude any shape in a variety of formulations to meet a wide range of design and performance requirements. Our complete tool and die shop is staffed with skilled technicians. We maintain a library of more than 400 section dies, one of which may fit your product design.

FABRICATED PARTS

We shape, flatten, curve, swedge, drill and perform other fabricating operations to make plastic parts ready for your production lines. Close tolerance, absolute uniformity, dimensional stability and high-gloss finish are standard production requirements at Yardley.

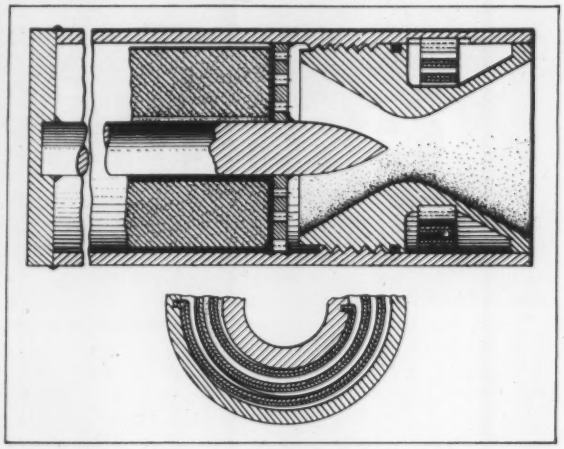
Write for Bulletin 180 — and for prompt quotation send us your prints

YARDLEY PLASTICS CO.
140-142 PARSONS AVE., COLUMBUS 15, OHIO

through one shaft end. Thickness of the cross arms determines torsional-deflection characteristics. *Patent 2,909,064 assigned to Lear, Inc., Grand Rapids, Mich., by John F. Schoeppel and David I. Critoph.*

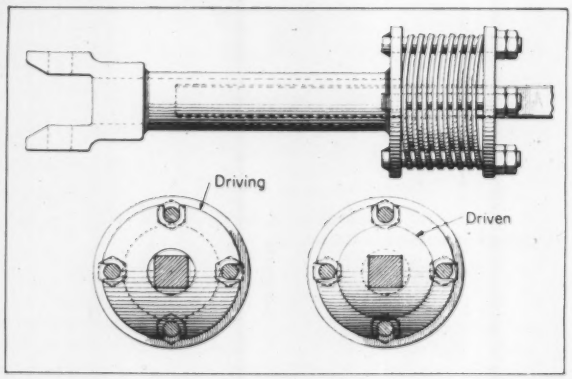
Temperature-Compensating Nozzle

In response to changes in temperature differential, a venturi-type orifice is moved axially with respect



to a stationary, coaxial, tapered pin to adjust automatically the flow of hot gas through a nozzle assembly. Changes in temperature difference between the inside and outside of the assembly actuate a bimetallic coil. The movable end of the coil rotates the orifice which is threaded, with a free fit, to a casing in which the pin is fixed. This motion changes the section area at the throat of the orifice. *Patent 2,909,032 assigned to Thiokol Chemical Corp. by Harold Davies.*

Adjustable Slip Clutch

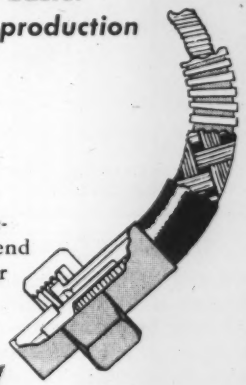


Power transmission members in a slip clutch are bowed round plates of two different sizes. The plates are assembled in a nested pack with sizes alternating. The larger, driving plates have round center holes which ride but do not engage a square output shaft, and peripheral slots which receive bolts to contain

HASEMANN
FLEXIBLE SHAFTING

Means fewer parts—Easier assembly—Reduced production time and costs!

Hasemann, a long respected name in the field invites you to discover a better way to solve your power transmission and remote control problems. Send specifications and our engineering department will design the unit best suited to your needs...without obligation!



Formerly
FLEXIBLE SHAFT DIVISION
ROBERTSHAW-FULTON
CONTROLS COMPANY

Hasemann FLEXIBLE SHAFT CO., INC.
112 Summit Ave., Chatham, N. J. • MErcury 5-8500

Circle 543 on Page 19

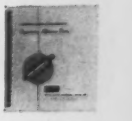
BHEW
Hydraulic Cylinders

- Basic Designs
- Superior Quality
- Specific Adaptations
- Application Engineering

BHEW SINGLE-ACTING GENERAL-PURPOSE CYLINDERS (1500 PSI PISTON STYLE SERIES) are designed around standard components but custom-built to suit *your* application. They're available in a variety of mountings (pin eye is standard) with adjustable or non-adjustable rod ends, with or without rod ends.

• Self-adjusting "U" cup seal on pistons • Self-adjusting rod wipers • Honed steel barrel, high-tensile, hard chrome-plated rod ends • Packings available for extreme high and low temperatures and most non-inflammable fluids.

Production parts save you money, do the job better! BHEW basic cylinders can easily be modified to fit your *specific* product applications. You benefit from production economies; you get custom-built cylinders.



Let's discuss your design and application problems —

FREE!

Write today for Hydraulic Cylinder Engineering Reference data — 78 dimensional basic designs for general-purpose and special-purpose double-acting and single-acting cylinders. SAVE TIME.

BENTON HARBOR ENGINEERING WORKS, INC.
622 Langley Avenue St. Joseph, Michigan

Circle 545 on Page 19

There's a
New DIAL HEAD AGASTAT®

for every time/delay/relay application

Here's what you get with every Agastat time/delay/relay

- **Easy adjustment**
- **Repeatable accuracy**
- **Instantaneous recycling**
- **Unaffected by voltage variations**
- **Low power consumption**

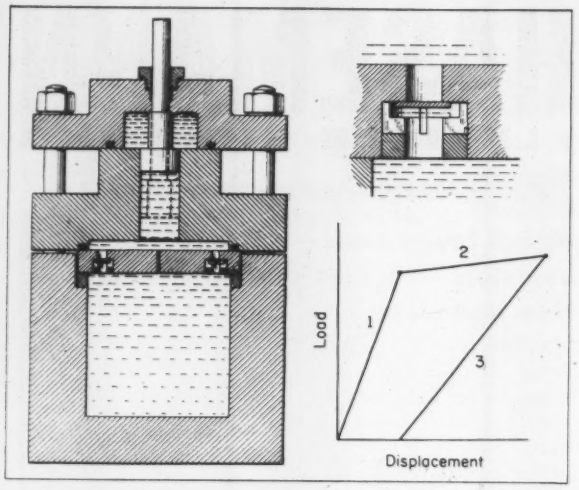
GET THE WHOLE STORY—write today for Bulletin No. SR-10 and find out how Agastat can help you to solve your time delay problems. Write to Dept. A35-1128.

AGA **ELASTIC STOP NUT CORPORATION OF AMERICA**
1027 Newark Avenue, Elizabeth, N. J.
Gasaccumulator Co., (Canada) Ltd., 12 Gower Street, Toronto 16, Ontario

Circle 544 on Page 19

the nest. The driven plates, too small to engage the bolts, have square center holes which fit the driven shaft. Overload overcomes the bends in the plates which slip with respect to each other. The load at which slip occurs can be adjusted by changing bolt tension. *Patent* 2,901,899 *assigned to Sperry Rand Corp., New Holland, Pa., by Richard K. Berky.*

Electrolytic liquid-level control is provided by a system in which the tank and the controlled fluid act as a wet battery. The battery circuit is closed when the liquid surface reaches a preset level. This action operates an electromagnet which opens a pressure circuit to constrict a flexible-tube section in the input line. *Patent* 2,904,063 *assigned to General Motors Corp. by James R. Wall and Robert D. Powell.*

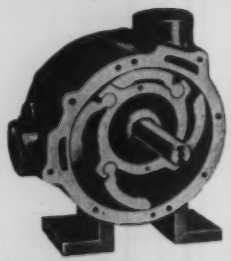


Adjustable Multiple-Rate Liquid Spring

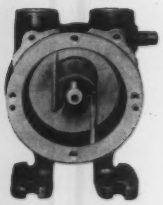
Heavy loads, applied suddenly, are absorbed in a three-stage cycle by a three-chamber assembly filled with a compressible liquid, such as a silicone fluid. Initial load is taken by a stepped piston operating in the first two chambers. Motion of the piston inward creates a partial vacuum in the first chamber and increased pressure in the second. This increased pressure is absorbed relatively slowly through disc valves leading to the third chamber. A small orifice between the second and third chambers restores original conditions. Cycle time is 20 to 30 milliseconds. Spring action can be adjusted by changing a spacer ring between second and third chambers. *Patent* 2,904,328 *assigned to Hughes Aircraft Co., Culver City, Calif., by George L. Williams.*

Copies of patents briefed in this department may be obtained for 25 cents each from the Commissioner of Patents, Washington 25, D. C.

Higher Vacuum . . . Suction . . . Pressure with Smaller Pumps!



Metal Vanes take up their own wear



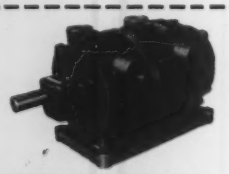
4-VANE TYPE. Vacuums to 20" Hg.; pressures to 15 lbs.; displacement to 162 c.f.m. Vanes hinged to pistons maintain continuous sealed contact with cylinder walls by centrifugal force. Small pistons, large air chambers, greater capacity.

2-VANE TYPE. Vacuums to 29.9" Hg.; pressures to 20 lbs.; displacement from 2.4 to 105 c.f.m. Automatic Vane adjusting lever forces wear-resistant steel blades to cylinder walls, preventing sticking or binding, maintaining positive vacuum or pressure.

COMPACT INTEGRAL PUMP and MOTOR

27" Hg. Vacuum
20 psig. Pressure

Two models, 3.6 c.f.m. and 7.2 c.f.m. Uses Leiman 2-vane pump. Fan-cooled for continuous operation. Automatic oiler, over load protection, ball bearings. Inlet filter and outlet separator for oil-free air.



DOUBLE CYLINDER MODEL

Provides both vacuum (suction) and pressure simultaneously. Needs only one motor—saves space. Models up to 20" Hg. Vacuum, 15 psig. pressure.

Save space, weight, horsepower — improve performance— get "lifetime" dependability with

LEIMAN Rotary Positive **AIR PUMPS**

Over 70 years' air engineering at your service

The exclusive Leiman hinged metal vane design provides 2 to 3 times more air space per weight and size of pump. Maintain original pump ratings and trouble-free operation for years because simplified design has fewer moving parts—all parts are durable cast iron and steel (not composition) — no gaskets or packing—quiet operation—little or no maintenance. Every pump tested before shipment. Over half million installed.

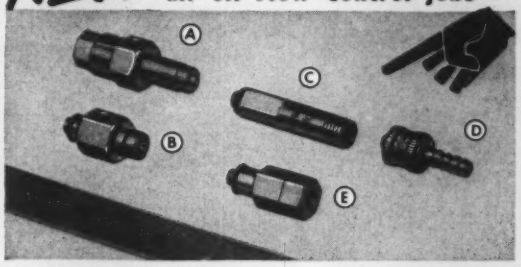
WRITE for 16 page Catalog, plus Application Book showing dozens of "how-to-do-it" blueprints.

LEIMAN BROS., Inc.
158 Christie St., Newark 5, N.J.
Established 1887

SEE OUR CATALOG IN SWEET'S FILE

Other types: Radiator-cooled • Fan-cooled • Water-cooled • Tank Models • Motor-driven Units • Gas Boosters • Air Motors

NEW MIDGETS for MAN-SIZED air-oil Flow Control jobs!



Ⓐ **MINIATURE FLOW CONTROL** — Operates on 1 lb. differential. Limited check one direction — full flow other. Recommended working range 0-250 psi. Air flow rate 3.6 CFM at 50 psi.

Ⓑ **MINIATURE NEEDLE VALVE** Precise control of air-oil in either direction. Range 0-2000 psi.

Ⓒ Ⓓ **MINIATURE QUICK CONNECT** — Air flow rate 2.7 CFM at 50 psi. Range 0-150 psi.

Ⓔ **MINIATURE CHECK VALVE** Poppet type, spring loaded. Full flow one direction only. Use in any position. Holds 0-2000 psi. Air flow rate 3.5 CFM at 50 psi.

Clippard Minimatics TRADE MARK

Write, NOW for NEW BULLETIN No. 8-59

Clippard INSTRUMENT LABORATORY, INC.

7380 Colerain Rd., Cincinnati 39, O. • Phone: JAckson 1-4261

Manufacturers of Miniature Pneumatic Devices, R.F. Coils, Electronic Equipment

Circle 547 on Page 19

Choose the *RIGHT* Speed Reducer for every job... *EVERY TIME*

Get this pocket-size engineering data book and complete catalog.

The handiest speed reducer guide available. Gives answers to ratios, horsepower, application, shock load, space, shaft position, etc.

Write, wire or phone today. No obligation.

ABART GEAR and MACHINE CO.

4821 WEST 16th STREET • CHICAGO 50, ILLINOIS

Circle 548 on Page 19

IT PAYS TO SEND YOUR FASTENER SPECIFICATIONS TO SPECIALISTS . . .

ERIE

BOLTS • STUDS • CAP SCREWS • NUTS
In Alloys • Stainless • Carbon • Bronze

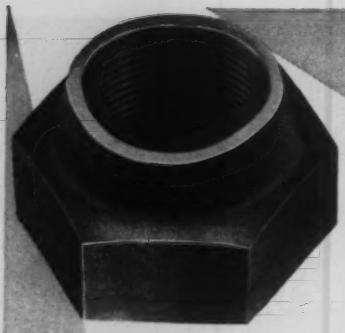
Your fastener specifications take shape with watchmaker's precision at ERIE. Our craftsmanship is backed by almost a half century of specialized experience. Since 1913, our sole business has been the production of fasteners to customer, government or national standards . . . fasteners to meet extreme temperatures, corrosion, tensiles, fatigue, impact, sheer stresses . . . fasteners for railroads, refineries, diesels, farm and earth moving equipment and other heavy machinery. This wealth of experience will return full value to you when you submit your fastener specifications to us.

A SUBSIDIARY OF
REPUBLIC INDUSTRIAL CORPORATION

ERIE BOLT & NUT CO.
Erie, Pennsylvania
Representatives in Principal Cities

Circle 549 on Page 19

New One-Piece "Conelok" with prevailing torque



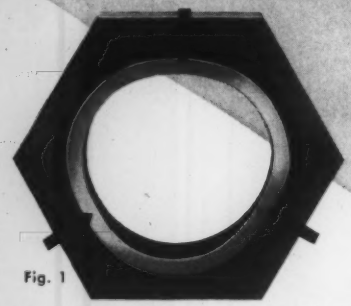


Fig. 1

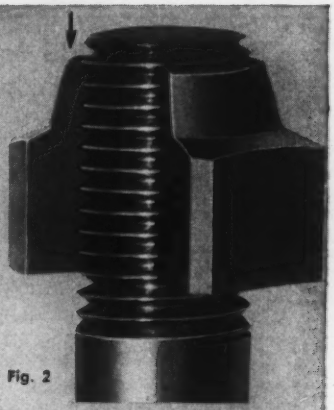


Fig. 2

Three sectors of the tapered portion of the CONELOK nut are preformed inwardly (Fig. 1). When the Nut is applied to a bolt, these conforming sectors are elastically returned to a circular configuration and create an inward and downward pressure which produces intimate contact between the load carrying flanks of the nut and bolt threads (Fig. 2). The shape of the cone sector displacement insures conformity with the mating bolt and maximum friction contact area. . . . The closed stress path in the locking portion of the nut and the advantageous distribution of locking pressure, produce a locking device of high fatigue life . . . and equivalent locking force is exerted at only a fraction of the stress of any slotted type locknut. CONELOK maintains its locking action through many re-applications. . . . It is adaptable to high, and low torque assemblies . . . to high torque stop-nut applications . . . and may be obtained in sizes from No. 10 through 1½", Full and Thick dimensions are "Standard". . .

Send for brochure which includes complete engineering specifications.

NATIONAL MACHINE PRODUCTS COMPANY

an SPS company 44250 UTICA ROAD UTICA, MICHIGAN

Circle 550 on Page 19

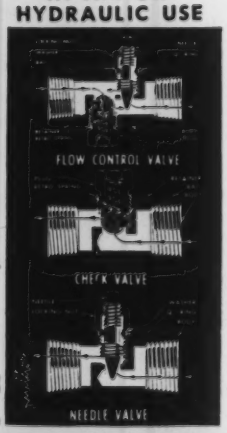
Get Easier, More Accurate Cylinder Speed Control

2,000 (brass or aluminum) and 5,000 (steel) p.s.i.

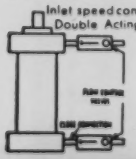
with **Pneu-Trol®** VALVES IN AIR OR HYDRAULIC USE

Pneu-Trol Valves combine in a short, compact body, a tapered fine thread needle for extremely accurate air or oil flow control and a floating retro ball check, which permits full flow in the opposite direction. Retro ball floats in most sensitive position to seat, requiring only a slight differential pressure to fully open or close it. Check Valve and Needle Valve incorporate single function features of Flow Control Valve. All valves available in 5 female pipe sizes — ⅛" to ¾". Valve bodies are made from brass, aluminum, steel or stainless steel. Attractive Prices — Immediate Delivery.

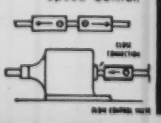
Write for Illustrated Circular and Price List.



Inlet speed control for Double Acting Cylinder.



Single Acting Cylinder Speed Control.



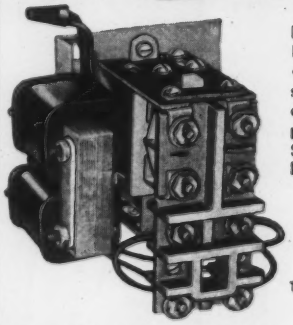
AUTOMATION AUTO PONENTS INC COMPONENTS

2925 GRANT STREET

BELLWOOD (Chicago Suburb) ILLINOIS

WARRICK Floatless Electrode Type LIQUID LEVEL CONTROLS . . .

give you all these advantages!



No moving parts in the liquid • Easy to install • No adjustments necessary • Unaffected by acids or caustics • Unaffected by pressure or temperature • Standard 2&3 pole units listed by U/L

Write for 32-page Catalog which gives complete specifications

Two pole control shown at left

YOU CAN USE OUR CONTROLS FOR:

- Single & multiple pumps
- Motor & solenoid valves
- High & low cutoffs & alarms
- Sewage & waterworks
- Chemical Industries
- Food & Dairy Industries
- OEM applications

Special controls to custom requirements

CHARLES F. WARRICK CO.

1964 W. Eleven Mile Road, Berkley, Michigan

Dep't 7 Telephone JOrdan 4-6667

Circle 551 on Page 19

Circle 552 on Page 19

COMAR

is your best source for TELEPHONE TYPE

RELAYS

Type TJC, one of Comar's many telephone types, combines features not usually found in a small relay. Lightweight, extra sensitive, large contact spring capacity, hinge-type armature, heavy duty yoke and independent twin contacts are some of its advantages. Inquiries invited.

We do our own HERMETIC SEALING • PLATING • PAINTING • SILK SCREENING

Hermetic sealing, plating, painting and imprinting is done in our own plant.

Speeds delivery, cuts costs. Send for details and complete catalog.

COMAR
ELECTRIC COMPANY
3349 Addison Street • Chicago 18, Illinois

RELAYS • SOLENOIDS • COILS • SWITCHES • HERMETIC SEALING

Circle 553 on Page 19

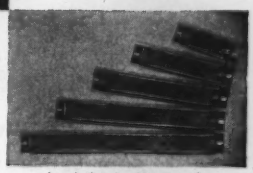
New
POWER RESISTORS
for FLIGHT USE

ELECTRO-FLEX

specialists in HEATING ELEMENTS

LESS SPACE—LESS WEIGHT

New lightweight, space-saving resistors permit substantial efficiencies and economies in aircraft and missile electronic apparatus. Units are mounted in direct contact with inner surface of chassis or case so that 25% to 40% of heat generated is emitted to atmosphere. Derating curves are available.



Available in the following ratings and sizes

Power Rating	Envelope Dimensions	Approx. Weight
40 Watts	7/32 x 1 5/16 x 4	.027 lbs. ea.
80 Watts	7/32 x 1 5/16 x 6	.040 lbs. ea.
120 Watts	7/32 x 1 5/16 x 8	.053 lbs. ea.
160 Watts	7/32 x 1 5/16 x 10	.067 lbs. ea.
200 Watts	7/32 x 1 5/16 x 12	.080 lbs. ea.

Insulation is silicone rubber—operable continuously at 450° F.
Mounting metal—Alclad aluminum.
Connection tabs—silver plated brass.

Special washers permit bolt or rivet mounting. Adhesive supplied provides good thermal transfer from resistor to mounting wall.

send for free illustrated booklet

Electro-Flex Heat, INC.
83 WOODBINE ST., HARTFORD, CONN. (CHapel 6-5413)

"FIRST with STANDARD ELEMENTS"

Circle 554 on Page 19

---

the **lightest**
most **compact**
FLEXIBLE GEAR COUPLING
YOU CAN BUY!

new
nyflex®
FLEXIBLE GEAR COUPLING
with
NYLON SLEEVE

Patent Pending

- No lubrication required
- Takes more misalignment than standard couplings
- Use horizontal or vertical
- Weighs only 3½ pounds
- Low in price
- Speeds to 5000 rpm
- 1⅝" max. shaft capacity

A sleeve weighing only four ounces, an entire assembly weighing only 3½ lbs.! The lightest, most compact flexible gear coupling yet! Never needs lubrication; takes up to 5 misalignment; operates to 150 F; wide range of capacities and speeds. The most important advance in couplings since Sier-Bath's flangeless design! Thirteen bore sizes available NOW from stock.

The complete Nyflex story is in this Bulletin N-1. Send for your copy now.

Sier-Bath
GEAR AND PUMP CO., INC.
FLEXIBLE COUPLING DIVISION
9254 HUDSON BLVD., NORTH BERGEN, N. J.

Member A.G.M.A.
Founded 1905

Circle 555 on Page 19

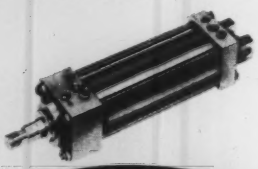
WHO'S SMILING?

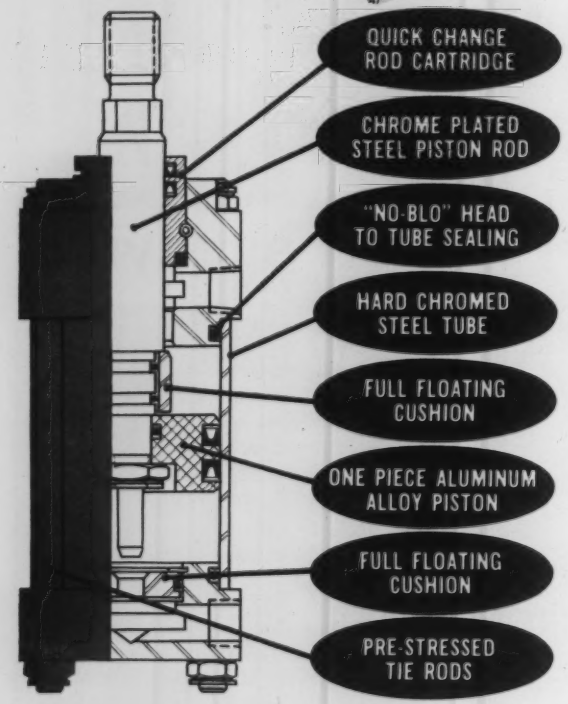
YOU, WHEN YOU DISCOVER THE DESIGN ADVANTAGES OF . . . .

LINDBERG

SQUAREHEAD CYLINDERS

DESIGN IN LINDBERG AND . . . ADD ALL THESE FEATURES!
and many more besides!




QUICK CHANGE ROD CARTRIDGE
CHROME PLATED STEEL PISTON ROD
"NO-BLO" HEAD TO TUBE SEALING
HARD CHROMED STEEL TUBE
FULL FLOATING CUSHION
ONE PIECE ALUMINUM ALLOY PISTON
FULL FLOATING CUSHION
PRE-STRESSED TIE RODS

CERTAINLY! Your choice of mounting styles • 7 bore sizes to 6" • Built to JIC recommendations • Standardized mounting dimensions.

WANT TO SMILE AGAIN!

FOR DETAILS OF THESE AND MANY OTHER FEATURES, WRITE FOR THESE BULLETINS TODAY.

SQUAREHEAD "S" LINE—	BULLETIN S-101
2000 PSI "H" LINE—	BULLETIN H-101
HEAVY DUTY "A" LINE—	BULLETIN A-101

for fast action on "specials" tell us what you need.

LINDBERG AIR and HYDRAULIC DIV.
TEER-WICKWIRE & CO.
1877 WILDWOOD AVE. • JACKSON, MICHIGAN

Circle 556 on Page 19

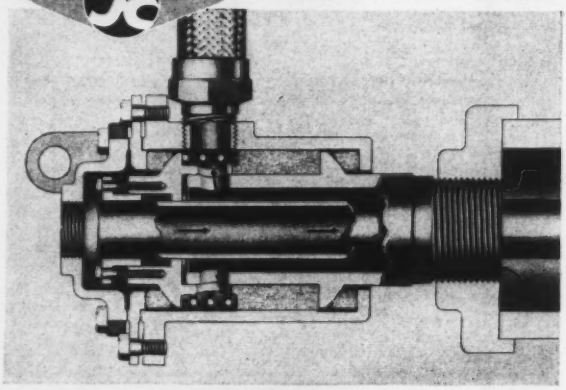
STANDS ALONE!

Type SN Johnson ROTARY PRESSURE Joint

There's not another rotary joint like the Johnson Type SN. Used where inlet or outlet pipe must rotate with the roll—on certain paper machines, drilled rolls of rubber or plastic mills and calenders, double shell dryers, and the like. Needs no external supports of any kind. Like all Johnson Joints the Type SN seals without packing, needs no lubrication or adjustment.

Investigate Johnson Joints for all steam-heated or water-cooled rolls. Handle Dowtherm, Monsanto Aroclors, hot oils too. Sizes to 8". For data on Type SN write for Bulletin N-2002.

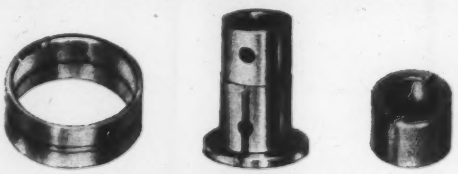
THE JOHNSON CORPORATION
811 Wood St., Three Rivers, Michigan



Circle 557 on Page 19

Moccasin BRONZE SLEEVE BEARINGS

Specialists in Special
CAST BRONZE BEARINGS



Free Engineering Service
Any Quantity—Any Size
Wide range of alloys poured to all specifications

SPECIFY BRONZE BEARINGS

Longest life and low cost • Quietness and wide availability
Low fluid friction, high fatigue and compressive strength

Write for Free Design Engineering Information

MOCCASIN BUSHING CO.
"Quality Bronze Since 1908"
MEMBER OF CAST BRONZE BEARING INSTITUTE
2000 Chestnut Street • Phone AM 7-9554
CHATTANOOGA 8, TENNESSEE

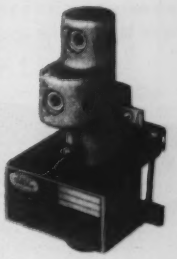
Circle 558 on Page 19

A lot at stake ?

depend on A+ Adlake

mercury to mercury relays

Wherever foolproof performance is important, depend on relays that can't burn, pit or stick. Depend on mercury-to-mercury contacts of Adlake, rated A+ for design and construction. The Adams & Westlake Company, Elkhart, Indiana. Original and Largest Manufacturer of Plunger-type Relays.



Illustrated — heavy duty 1101 —87T type with compression terminals.

SEND TODAY FOR FREE CATALOG

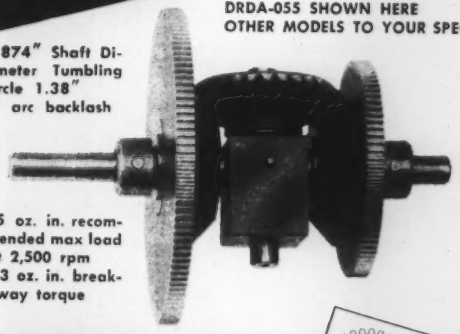
Circle 559 on Page 19

IN STOCK IMMEDIATE DELIVERY

PRECISION 3-GEAR DIFFERENTIALS

DRDA-055 SHOWN HERE
OTHER MODELS TO YOUR SPECS.

.1874" Shaft Diameter Tumbling circle 1.38"
8' arc backlash



75 oz. in. recommended max load at 2,500 rpm
0.3 oz. in. breakaway torque

FREE!

Send for 16 pg. Supplement "C" to Dynaco E88 Catalog. Shows complete line & specs. on Precision Stock Differentials including Precision Hollow & Solid Shafts, Bearingless, Face Gear and 3-Gear Models.

DYNAMIC GEAR CO. INC.
AMITYVILLE, NEW YORK

Circle 560 on Page 19

CLOSURES

- Metal or Plastic Caps or Plugs to protect threads, tubes, machined parts, reamers, cutters, tools.
- Protect against thread damage, dust, dirt, and moisture.
- For inside and outside application.
  All sizes. Immediate delivery.

METAL Caps to cover AN & SAE threads

PLASTIC tapered caps and plugs

METAL plugs for AN & SAE threads

PLASTIC tube cap for AN & SAE parts

Clover closures are made in metal and tough plastic polyethylene. They are made in caps, plugs and special shapes to fit parts tightly, offering completely sealed protection during manufacture, shipping and storage. Backed by years of closure experience. Write for low prices and complete information.

Send coupon today!

Gentlemen: Please send samples and prices of closures in Polyethylene ☐ Aluminum ☐

Name.....

Address.....

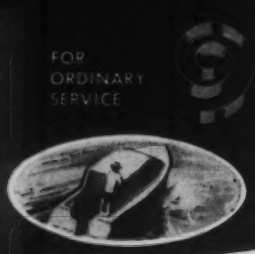
City.....

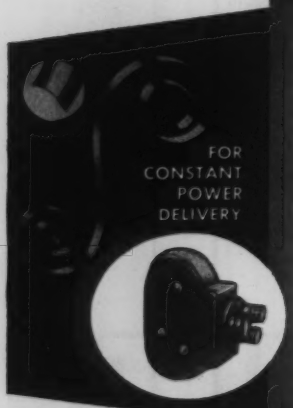
CLOVER INDUSTRIES, INC. 596 Young Street Tonawanda, N Y

Circle 561 on Page 19

Which Kind of SANDVIK SPRING PERFORMANCE *Fits YOUR Product?*

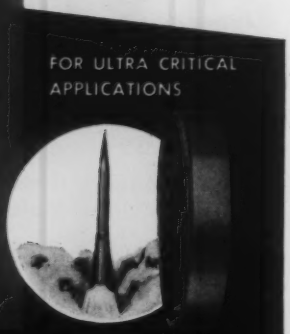
Sandvik SPIRAL springs provide long-lived, low-cost service for starters, guard return springs, toys or tension devices where constant torque is not critical.



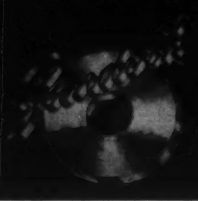


Sandvik CROSS-CURVED springs have a dual tension produced by winding the spring against both its tempered spiral and against a special convex curvature across the width of the strip. The longer, more even energy release provides uniform power for timing instruments, carriage return springs, movie cameras and other high performance applications.

Sandvik 2R25 stainless springs are a super quality which give 5 to 10 times longer performance than ordinary carbon steel springs and can take the corrosive attacks of varying atmospheres too. For applications where performance demand outranks cost, such as in missiles, aircraft and special instruments.



These examples give you some idea of Sandvik's ability to supply the spring that fits your application in both performance and cost. You can draw on Sandvik's fund of over 30 years of spring experience to help select or develop the exact size and type that's right for your product. Ask for further information or send us the data on your spring application.



SANDVIK STEEL, INC.
Fair Lawn, New Jersey
Tel. SWarthmore 7-6200
In New York City Algonquin 5-2200
Cleveland • Chicago • Detroit • Los Angeles

ALMOST ACCURATE IS NOT GOOD ENOUGH

INLINE RELIEF VALVES

CIRCLE SEAL RELIEF VALVES...

provide the **ACCURACY and RELIABILITY** required for critical applications. These valves can be installed in virtually any liquid or gas system. An "O" ring seal provides dead tight sealing. Each valve is precision-designed for minimum flow restriction. Other significant advantages include ease of installation, tamper-proof setting, and in-line construction.

5100 Series—10 to 2400 psi. **500 Series**—0.5 to 140 psi.

CHECK VALVES

SHUTOFF VALVES

PLUG VALVES

POPOFF RELIEF VALVES

Complete engineering data available. Write today!

CIRCLE SEAL
precision valves

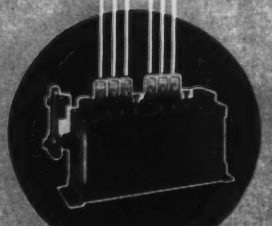
Circle Seal Products Co., Inc.
2181 East Foothill Blvd., Pasadena, Calif.

Circle 563 on Page 19

dependable accurate lubrication

Put more **sense** in your lubrication **dollars**—with a Manzel Force Feed Lubricator. Outstanding Vacuum Pumping Units cut maintenance cost, increase accuracy, solve liquid sight feed problems. See your Manzel field engineer.

MANZEL



FREE CATALOG *gives complete data on all Manzel lubricators.*

Manzel

276 Babcock Street
Buffalo 10, N. Y.

Specialists in metering pumps and lubricators since 1893

Circle 562 on Page 19

Circle 564 on Page 19

Precise-Uniform

Gillen TAPER PINS

¼" per foot

For Precision Assembling •
Available in All Metals •
Complete Range of Sizes •
Rust Resistant Coating •

Standard Turned Pins •
Centerless Ground Pins •
Threaded End Pins •

Immediate Delivery •

Diameters From 7/0 to No. 14

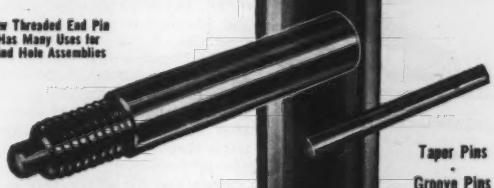
•

Up to 13" Lengths

•

Write For TAPER PIN Price List and Samples

New Threaded End Pin Has Many Uses for Blind Hole Assemblies



Taper Pins
•
Groove Pins
•
Machine Keys
•
Woodruff Keys

John Gillen Company

Keying and Pinning Devices

2568 South 50th Avenue • Cicero 50, Illinois

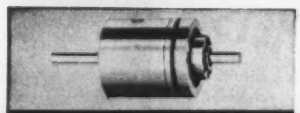
A Subsidiary of Standard Railway Equipment Manufacturing Company

Circle 565 on Page 19

Compact – Quiet – Swift

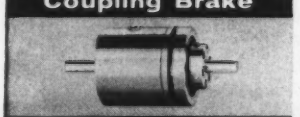
Simplatrol

FIXED FIELD ELECTRIC CLUTCHES



Electric Clutch

Coupling Brake



Clutch Coupling

Three styles from 7/8" to 3 1/8". Torque output from 10 oz. inches to 100 lb. inches.

In Miniature & Small Sizes

Introduced only a few short months ago, Simplatrol Fixed Field Electric Clutches have found popular application wherever space is tight, noise is objectionable and performance requirements are rigid.

PATENTED DIAPHRAGM ACTION Makes the Difference

No other electric clutch and brake can duplicate the patented Simplatrol diaphragm . . . the *only* moving part in Simplatrol Fixed Field Clutches. Here is a proved advantage . . . offering an absolute minimum of maintenance.

Ask for Simplatrol Fixed Field Literature

Simplatrol products corp.

24-5 SALISBURY ST., WORCESTER, MASS.

Representation in Key Industrial Areas

404-8

Circle 566 on Page 19

TROMBETTA SOLENOID CORP.

MILWAUKEE WISCONSIN U.S.A

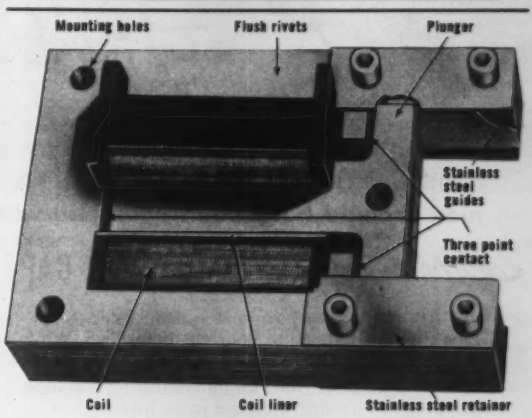
329 N. Milwaukee Street • Phone BRoadway 1-8347

NA-700 LINE OF SOLENOIDS

The ultimate design in Guided T Plunger Solenoids

Patented March 10, 1959
Developed in 1952
Patent No. 2,877,390

WE DESIGNED THEM!
WE DEVELOPED THEM!!
WE PATENTED THEM!!!
THEY ARE OURS!!!!



No clatter! No chatter!!

FEATURES

Positive three point contact
Heavy stainless steel guides

RESULTS

Longest life expectancy; reliable operation throughout entire life; silent operation in sealed position; mountable in any position, at any angle; no heavy grease required to cover up poor design; no grunting when mounted horizontally.

AVAILABLE

In a multitude of standard sizes, pull or push type; also custom built to satisfy customer's requirements; also for OEM, and replacement trade.

TROMBETTA has the original solenoid. Don't let anyone sell you imitations. Request additional information.

"TROMBETTA"

is the answer to:

ALL SOLENOID QUESTIONS

Circle 567 on Page 19

UTTERLY RIDICULOUS!

He wants to know why $5,000 in equipment was ruined...when for a few pennies it could have been equipped with

S.S.White PLASTIC PLUGS AND CAPS!

Don't let this happen to your customer! S.S. White plastic plugs and caps afford complete protection against damage to vital equipment during handling . . . shipping . . . storage. Remove in an instant, too, and never shred. He'll appreciate your forethought.

And *you* will appreciate their rapid installation that saves hours of production time . . . and, of course, their low cost!

Two lines to choose from:

The quality line – of rigid acetate...tough, non-brittle, impervious to petroleum-base oils and greases, outstanding impact strength.

The economy line – of elastoplastic vinylite . . . a "non-slip grip" for rapid installation and removal, a "stay-put fit."

WRITE FOR FREE BULLETIN
(P5708) and samples
(please state size and type)

S.S.White PLASTICS DIVISION

1054

Dept. 4P, · 10 East 40th Street · New York 16, N.Y.

New...from MARSH!

Conduit-type Mastermite. Grommet-type also available.

Small solenoid valves that fill a BIG order

Designed to meet the need for positive-acting tight-seating valves for use on wide variety of media, including oxygen, hydrogen, acetylene, etc.

Two Types:
Conduit type and grommet type. Port sizes 1/8" and 1/4" NPT.

Ten orifice sizes:
3/64" through 1/4".

Wide range of voltages:
Standard with 115 V. A. C. but also available in 12, 24, 208, 230, 460 V. A.C.

Pressure to 540 psi.

Small, but with more strength in the Marsh manner. Coils never overheat. Entire assembly leak tight. Remarkably quiet operation. Cleanable without breaking connections. Used in any position. Bodies either brass bar stock or 18-8 stainless steel. All moving parts stainless. Underwriters' approved for use on oxygen and hydrogen and as safety valves.

Write for new bulletin

MARSH INSTRUMENT COMPANY
Dept. B, Skokie, Illinois
Division of Colorado Oil and Gas Corporation
Marsh Instrument & Valve Co., (Canada) Ltd., 8407 103rd St., Edmonton, Alberta, Canada, Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas.

Circle 569 on Page 19

For HIGHEST ELECTRICAL & MECHANICAL *Efficiency!*

New

JONES 2400 SERIES PLUGS & SOCKETS

Improved Socket Contacts. Four individual flexing surfaces. Positive contact over practically their entire length.

Both Plug and Socket Contacts mounted in recessed pockets greatly increasing leakage distance, INCREASING VOLTAGE RATING. Plug and Socket Contacts cadmium plated. Add to appearance of your equipment. Interchangeable with Jones 400 Series.

Ask for Catalog 22, Complete line Jones Plugs, Sockets, Terminal Strips.

P-2406-CCT
Plug—with cable clamp in top.

S-2406-SB
Socket with shallow bracket for flush mounting.

Jones
HOWARD B. JONES DIVISION
CINCH MANUFACTURING COMPANY
CHICAGO 24, ILLINOIS
DIVISION OF UNITED-CARR FASTENER CORP.

Circle 568 on Page 19

Circle 570 on Page 19

Weckesser

CABLE CLAMPS

Black Nylon for high temperature and other severe service conditions.

A STYLE AND SIZE FOR EVERY CABLE FASTENING REQUIREMENT

Weckesser Cable Clamps offer superior insulating properties, high strength, light weight . . . with *no* rust or corrosion.

Non-circular shapes also available. Immediate delivery from on-hand stocks.

of economical Ethyl-Cellulose for maximum service at minimum cost.

WRITE TODAY FOR FREE SAMPLES AND PRICE SHEET

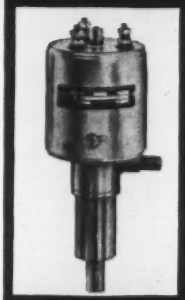
Weckesser COMPANY

5715 Northwest Highway • Chicago 46, Ill.

Circle 571 on Page 19

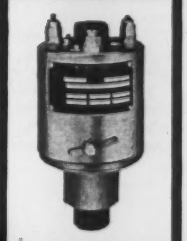
SPEED SENSITIVE SWITCH GOVERNORS

Adjustable within a speed range while running



1 Switch UNDERSPEED OR OVERSPEED

2 Switches UNDERSPEED AND OVERSPEED



3 Switches UNDERSPEED, INTERMEDIATE AND OVERSPEED

All "STANDARD" Speed Sensitive Switches can be furnished to TRIP at any speed between 500 and 6000 RPM. On special order higher or lower speed operation can be supplied. Also special body styles, mounting pads, drives, terminal connectors and caps are available.

Write for Bulletin 504 for further information

SYNCHRO-START PRODUCTS

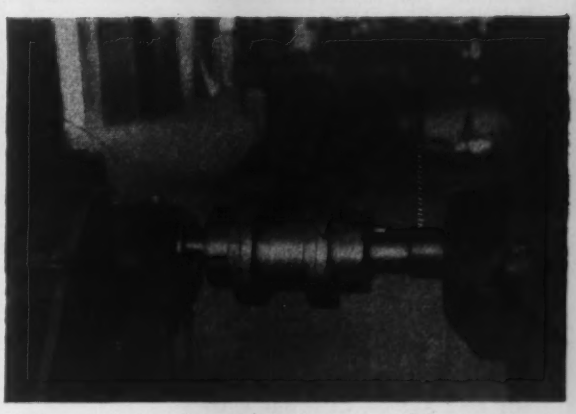
Since 1932

8151 NORTH RIDGEWAY AVENUE • SKOKIE, ILLINOIS

Circle 572 on Page 19

WALDRON COUPLINGS....

SAFEGUARD MACHINERY NEED NO MAINTENANCE



Waldron standard coupling on crude oil pumps on 20" line from Wyoming to Indiana.

John Waldron makes a complete line of standard couplings. They are all designed to transmit maximum power smoothly and safeguard the connected machines from the effects of misalignment which occur during operation. And, outside of periodic lubrication, the couplings never need maintenance. Hence, once these couplings are installed they will run continuously over the years (often outlasting the equipment they couple) with minimum care and maximum efficiency.

Waldron can stand behind these claims because their standard couplings are made of forged steel and are machined under controlled conditions. The two, one piece cover sleeves and spacer function as a single unit with no flexible metal parts to bend or break. Couplings are oil tight and dust and moisture free.

There are plenty of rough bore standard couplings on the shelves at Waldron and other locations throughout the country ready for immediate delivery. Finished bored couplings may be ordered to customer specifications.

MFR

JOHN **WALDRON** CORPORATION

Subsidiary of Midland-Ross Corporation

NEW BRUNSWICK, NEW JERSEY

Circle 573 on Page 19

Mechanical Engineers

ARE YOUR CREATIVE INSTINCTS BEING BLUNTED?

This is the frequent complaint of many engineers. Since its foundation in 1930, Battelle has always encouraged its professional people to think beyond the confines of routine assignments . . . and we listen carefully to promising ideas.

Some of Battelle's most noteworthy accomplishments have developed from basic ideas presented by individual staff members. Many assignments from sponsors expand beyond original concepts because of the challenging and creative attitude of Battelle's professional staff.

If you are an M.E. graduate with strong creative instincts, you should investigate a career with Battelle.

Battelle's approach to industrial research is so broad and diversified that you see your ideas advance from theory to experimental design, to laboratory research, to working prototype, to production prototype and to application in our sponsor's plant.

We need creative-minded mechanical engineers in these fields: Machine design and development, stress analysis, vibrations, internal combustion engines, propulsion, equipment systems, instrumentation, reactor engineering and related fields.

Salaries competitive, with attractive benefits program. Write for an interview today to:

Russell S. Drum
BATTELLE MEMORIAL INSTITUTE
505 King Avenue, Columbus 1, Ohio

Circle 574 on Page 19

DESIGN ENGINEERS MECHANICAL

Chicago Pneumatic has several positions open for Designers interested in Diesel Engines, Gas Engines, Stationary Gas Compressors, and Portable Compressors.

These Design Positions require a minimum of five years design experience on reciprocating machinery, such as Pumps, Compressors, or Engines.

Please send Resume, in confidence, to —

J. C. SANFORD, Personnel Director,
Chicago Pneumatic Tool Company,
Franklin, Pennsylvania.

Put your imagination to work at $13,000 per year

SENIOR MACHINE DESIGNERS

The expanding RCA Semiconductor Division offers an opportunity to join a stable, progressive organization engaged in commercial work.

An outstanding opportunity to conceive, design, and put into actual operation manufacturing equipment for this dynamic industry is available to experienced designers of proven ability.

Previous experience in designing automatic precision equipment for the assembly, fabrication, and processing of intricate parts will further qualify the applicant for a position with this organization.

A Degree is desirable

- Financial Educational Assistance
- Relocation Assistance Available
- Suburban Communities

Send Resume Today to
MR. J. B. DALY
REPLIES CONFIDENTIAL

RADIO CORPORATION OF AMERICA
Semiconductor & Materials Division
Somerville, New Jersey

Circle 575 on Page 19

ENGINEERS AVAILABLE OR WANTED

AVAILABLE: Design Engineer for board work. Offering you competence, ability and twenty years' experience on design of product, power press dies, automatic and other machinery, production tools; quality draftsmanship; ingenuity and originality on development of ideas. Temporary engagements or projects. Per Diem fee. Any location. Address: Boxholder, 202 Back Bay Postal Annex, Boston, Massachusetts.

WANTED: Bausch & Lomb Optical Co. Rochester, N. Y. has openings in an expanding field. Bausch & Lomb Optical Co. has been a leader in precision optics for many years. This leadership has been based on skills and experience of a few specialists in the "art" of optics and precision optical machinery. The rapid moving technological world of today demands that this skill and ability be applied to many fields to support both civilian and military advances. To accomplish this a major increase in engineering staff will be required. This increase is primarily in the Mechanical Design Department of Consumer Products, Special Products and Scientific Instruments. Experienced Mechanical Design Engineers and Draftsmen (no optical experience required) who are interested in positions in a rapidly expanding field are invited to call or write Mr. A. L. Johnson, Bausch & Lomb Optical Co., Rochester 2, New York.

Circle 576 on Page 19

Advertising Index

Abart Gear and Machine Co. 221
Adams & Westlake Co., The 225
Aeroquip Corporation 48, 49
A'G'A Division, Elastic Stop Nut Corporation of America 219
Allis, Louis, Co., The ..54, 55, 56, 57, 58, 59
Aluminum Company of America 93
American Brass Co. 31
American Cast Iron Pipe Co., Special Products Division 86
American Machine and Metals, Inc., Hunter Spring Co. Division 65, 66
American Machine and Metals, Inc., United States Gauge Division 92
American Nickeloid Co. 73
American Pulley Co., The, Power Transmission Division 43
American Sealants Co. 41
American-Standard, Industrial Division 195
American Stock Gear Division, Perfection Gear Co. 205
American Welding & Mfg. Co., The 32
Armstrong Cork Co., Industrial Division 110
Arrow-Hart & Hegeman Electric Co., The 202, 203
Atlas Chain & Manufacturing Co. 190
Auto-Ponents, Inc. 222

Babcock & Wilcox Co., The, Tubular Products Division 5
Barksdale Valves, Control Valve Division .. 216
Battelle Memorial Institute 230
Bellows Co., The, Division of International Basic Economy Corporation 109
Benton Harbor Engineering Works, Inc. 219
Blood Brothers Universal Joints Division, Rockwell-Standard Corporation 100
Bodine Electric Co. 1
Borg-Warner Corporation, Rockford Clutch Division 210
Boston Gear Works 162
Bound Brook Oil-less Bearing Co. ..... Inside Front Cover
Bridgeport Brass Co. 183
Brown & Sharpe Mfg. Co., Hydraulics Division 209
Bruning, Charles, Co., Inc. 47

Carpenter Steel Co., The 186
Casting Engineers 198
Chicago Pneumatic Tool Co. 230
Chicago Rawhide Manufacturing Co. 2
Chrysler Corporation, Marine and Industrial Engine Division 105
Cinch Manufacturing Co., Howard B. Jones Division 228
Circle Seal Products Co., Inc. 226
Clippard Instrument Laboratory, Inc. 221
Clover Industries, Inc. 225
Colorado Oil and Gas Corporation, Marsh Instrument Co. Division 228
Columbia-Geneva Steel Division, United States Steel Corporation 29
Comar Electric Co. 223
Continental-Diamond Fibre, A Subsidiary of The Budd Co. 67
Copperweld Steel Co., Aristoloy Steel Division 11
Corning Glass Works 189
Cuno Engineering Corporation, The 213

Dayton Industrial Products Co., A Division of The Dayton Rubber Co. 91
Dayton Rubber Co., The, Dayton Industrial Products Co. Division 91
Detroit Power Screwdriver Co. 163
Dodge Steel Co. 88
Dollinger Corporation 106
Drop Forging Association 46
Du Pont, E. I., de Nemours & Co., Inc. 50
Durez Plastics Division, Hooker Chemical Corporation 185
Dynamic Gear Co., Inc. 225

Eastman Manufacturing Co. 158
Elastic Stop Nut Corporation of America, A'G'A Division 219
Electric Steel Foundry Co. 157
Electro Devices, Inc., Servospeed Division .. 182
Electro-Flex Heat, Inc. 223
Elgin Metalformers Corporation 82
Erie Bolt & Nut Co. 221

Fastex Division, Illinois Tool Works 35
Fawick Corporation, Fawick Airflex Division 165
Fellows Gear Shaper Co., The 95
Fenwal, Inc. 96
Flexonics Corporation 81

Garlock Packing Co., The, Plastics Division, United States Gasket Co. 44
Gear Specialties, Inc. 7
General American Transportation Corporation, Parker-Kalon Division 80
General Aniline & Film Corporation, Ozalid Division 171
General Motors Corporation, Hyatt Bearings Division 37, 38, 39, 40
Gillen, John, Co. 227
Gits Bros. Mfg. Co. 191
Gleason Works 9
Globe Industries, Inc. 98
Goodrich Chemical, B. F., Co., A Division of The B. F. Goodrich Co. 211

Hamilton Foundry, Inc. 45
Hasemann Flexible Shaft Co., Inc. 219
Heim Co., The 192
Heinze Electric Co. 188
Hooker Chemical Corporation, Durez Plastics Division 185
Houdaille Industries, Inc., Manzel Division .. 226
Hunter Spring Co., A Division of American Machine and Metals, Inc. 65, 66
Hyatt Bearings Division, General Motors Corporation 37, 38, 39, 40

Illinois Tool Works, Fastex Division 35
Illinois Tool Works, Shakeproof Division 89
Imperial Brass Mfg. Co., The 61
Industrial Press, The 166
International Basic Economy Corporation, The Bellows Co. Division 109

Jeffrey Manufacturing Co., The 77
Jessop Steel Co. 97
Johnson Bronze 64
Johnson Corporation, The 224
Jones, Howard B., Division, Cinch Manufacturing Corporation 228

Kaydon Engineering Corporation, The 21
Kennametal, Inc. 208
Keystone Steel & Wire Co. 75

Laminated Shim Co., Inc. 194
Lancaster Glass Corporation 193
Leiman Bros., Inc. 220
Lewellen Manufacturing Co. 15
Lincoln Engineering Co., Division of The McNeil Machine & Engineering Co. 107
Lindberg Air and Hydraulic Division, Teer-Wickwire & Co. 224
Linear, Inc. 198
Link-Belt Co. 16, 51
Lord Manufacturing Co. 94

MACHINE DESIGN

Penton Building, Cleveland 13, Ohio
Main 1-8260

BUSINESS STAFF

ROBERT L. HARTFORD
Business Manager

MARY L. CALLAHAN
Advertising Service Manager

RICHARD A. TEMPLETON
Research and Circulation Manager

BARBARA O'LEARY
Staff Assistant

ROBERT E. LESSING
Production Manager

District Offices

New York 17 .....60 East 42nd St.
RUSSELL H. SMITH, JAMES A. STANGARONE
Murray Hill 2-2581

Simsbury, Conn. .....17 Deerfield Lane
ALAN C. BUGBEE
Oldfield 8-4764

Rochester 10 .....33 Landing Rd. S.
EDWARD F. CLANCY
Greenfield 3-1223

Dresher (Philadelphia), Pa. ....1335 Harris Rd.
CHANDLER C. HENLEY
Mitchell 6-2585

Cleveland 13 .....Penton Bldg.
JACK W. WALTON, DON J. BILLINGS
Main 1-8260

Detroit 35 .....15800 West McNichols Rd.
CHARLES F. REINER, ARNOLD T. SUHART
Broadway 3-8150

Chicago 11 .....520 North Michigan Ave.
HOWARD H. DREYER, ROBERT Z. CHEW
DONALD A. IVINS, CHARLES F. REINER
Whitehall 4-1234

Los Angeles 36 .....5943 West Colgate Ave.
F. J. FULLER
Webster 1-6865

San Francisco 4 .....57 Post St.
Robert W. Walker Co.
Sutter 1-5568

Griffin, Ga. .....112½ East Solomon St.
FRED J. ALLEN
Griffin 8-8681

Clearwater, Fla. .....1954 Jeffords Dr.
H. G. ROWLAND
(Clearwater) 31-4121

Dallas 35 .....818 Exchange Bank Bldg.
JAMES H. CASH
Fleetwood 1-4523

London, S.W.1 .....2 Caxton St., Westminster

Published by
THE PENTON PUBLISHING COMPANY

G. O. HAYS .....Chairman
R. C. JAENKE .....President
F. G. STEINEBACH ....Vice President and Secy.
F. O. RICE .....Vice President
J. P. LIPKA..Treasurer and Assistant Secretary

Also Publisher of
STEEL, FOUNDRY, NEW EQUIPMENT DIGEST, AUTOMATION

MACHINE DESIGN is sent at no cost to management, design and engineering personnel whose work involves design engineering of machines, appliances, electrical and mechanical equipment, in U. S. and Canadian companies employing 20 or more people. Copies are sent on the basis of one for each group of four or five readers. Consulting and industrial engineering firms, research institutions and U. S. government installations, performing design engineering of products are also eligible.

Subscription in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $25. Published every other Thursday and copyrighted 1959 by The Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.

BPA NEP

backtalk——

Light Side of Lighter-Than Air

No, this is not a group of brave Earthlings capturing a Martian Gulliver — these men are part of another group of heroes who are responsible for building and maintaining the huge balloon figures which star in parades such as Macy's annual Thanksgiving Day affair. Building figures like the Spaceman is the fun part of Goodyear's blimp business; the serious side is covered in our article on the "breathing" apparatus of Navy radar airships, Page 24. Keeping the 70-ft tall Spaceman aloft, incidentally, requires 15,000 cu ft of helium—a mere drop in the envelope of a 1.5 million cu ft radar blimp.

Author Guide

MACHINE DESIGN author Albert Woodruff Gray, an authority on patent law and procedure, is also something of a philosopher. He garnishes his letters with quotations and sometimes verse, such as the following writer's prayer:

I pray Thee make my column read
And give me thus my daily bread;
Endow me, if Thou grant me wit,
Likewise with sense to mellow it.

Mr. Gray's current "column" in MACHINE DESIGN is the article, "Reliability or Liability?" beginning on Page 112.

Dollars for Diecasting

Skillful "die casting" can fatten (or deflate) a man's wallet, as anyone who has ever rolled the little spotted cubes knows, but now another type of contest offers cash awards in the diecasting field on a no-risk basis. The New Jersey Zinc Co., producer of Zamak alloy for die casting, is sponsoring a competition for the best examples of lightweight, thin-wall zinc diecastings used in product design. Awards of $200, $100, and $50 will be made to three castings designers. Purpose of the contest is to stimulate interest in "imaginative and progressive use" of zinc diecastings in designing or redesigning industrial and consumer products. To qualify, entries must be of unusually lightweight construction. Entry blanks and complete details may be obtained from "Lighter Than You Think" Contest Editor, New Jersey Zinc Co., 160 Front St., New York 38, N. Y. Contest closes January 31, 1960.

Suggestions for Suggestions

In recent years, brainstorming has been all the rage in generating new ideas; before that employees were supposed to *Think;* now workers at U. S. Steel are encouraged to "Scamper" for ideas that will improve their jobs—and bring them cash awards. Here, spelled out, is the "Scamper" suggestion plan approach:

S—Substitute. What different material might be used? How about different equipment? Different people? Another place?

C—Combine. How might a substitution be combined with an adoption? How about combining several into one?

A—Adapt. Can another procedure or idea be adapted to the situation?

M—Modify. Are fewer steps possible? How about making it smaller, bigger, lighter, lower, higher, condensed? Why not try it faster or slower?

P—Put to other uses. How about doing different things with the same equipment, or report, or people?

E—Eliminate. What would happen if this step or piece of equipment were by-passed? Or if a whole operation were omitted? Suppose the information, equipment, people, and/or time were not available to continue as usual.

R—Rearrange. What would happen if the sequence were reversed or otherwise shuffled? How about shifting responsibility to different people? How about interchanging people or equipment? Why not a different layout or pattern or format?

Advertising Index

McGill Manufacturing Co., Inc. 74
McNeil Machine & Engineering Co., Lincoln Engineering Co. Division 107

Madison-Kipp Corporation 196
Manhattan Rubber Division, Raybestos-Manhattan, Inc. 62, 63
Manzel, A Division of Houdaille Industries, Inc. 226
Marsh Instrument Co., Division of Colorado Oil and Gas Corporation 228
MB Electronics, A Division of Textron Electronics, Inc. 103
Mead Specialties Co. 87
Messinger Bearings, Inc. 234
Minnesota Mining and Manufacturing Co., Adhesives, Coatings and Sealers Division 83
Moccasin Bushing Co. 224
Morganite, Inc. 178

National Acme Co., The 52, 72
National Machine Products Co. 222
National Screw & Mfg. Co., The 168

Ozalid, Division of General Aniline & Film Corporation 171

Packing Division, Raybestos-Manhattan, Inc. 62, 63
Parker-Kalon, A Division of General American Transportation Corporation 80
Peerless Electric Co., The, Electric Motor Division 108
Perfection Gear Co., American Stock Gear Division 205
Perkins Machine and Gear Co. 184
Pheoll Manufacturing Co., Inc. ..Inside Back Cover
Philadelphia Gear Corporation 60
Plastic Products Division, Raybestos-Manhattan, Inc. 62, 63
Polymer Corporation of Pennsylvania, The .. 200

Radio Corporation of America, Semiconductor & Materials Division 230
Raybestos-Manhattan, Inc. 62, 63
Reese Metal Products Corporation 166
Renewal Service, Inc. 42
Republic Steel Corporation 84, 85
Robbins & Myers, Inc. 78, 79
Rochester Manufacturing Co., Inc. 180, 181
Rockford Clutch Division, Borg-Warner Corporation 210
Rockwell-Standard Corporation, Blood Brothers Universal Joints Division 100
Roller Bearing Company of America 206
Roth Rubber Co., Division of Vapor Heating Corporation 102
Ruthman Machinery Co., The 182

Sandvik Steel, Inc. 226
Servospeed, Division of Electro Devices, Inc. 182
Set Screw & Mfg. Co. 188
Shakeproof, Division of Illinois Tool Works 89
Sier-Bath Gear and Pump Co., Inc. 223
Simplatrol Products Corporation 227
SKF Industries, Inc. 104
Snap-Tite, Inc. 161
Solar Aircraft Co. 212
South Chester Corporation, Southco Division .. 101
Southco Division, South Chester Corporation .. 101
Sperry Rand Corporation, Vickers, Inc. Division 199
Sperry Rand Corporation, Vickers, Inc., Electric Products Division 207
Stackpole Carbon Co. 201
Standard Pressed Steel Co., Flexloc Locknut Division 173
Stearns Electric Corporation 169
Struthers-Dunn, Inc. 197
Sundstrand Corporation, Sundstrand Hydraulics Division 175
Synchro-Start Products, Inc. 229

Tennessee Coal & Iron Division, United States Steel Corporation 29
Teer-Wickwire & Co., Lindberg Air and Hydraulic Division 224
Textron Electronics, Inc., MB Electronics Division 103
Thomson, Judson L., Mfg. Co. 215
Timken Roller Bearing Co., The, Steel and Tube Division .....Back Cover
Tinnerman Products, Inc. 179
Torrington Co., The 13
Torrington Manufacturing Co., The 167
Trabon Engineering Corporation 76
Trombetta Solenoid Corporation 227

Union Carbide Corporation, Union Carbide Plastics Co. Division 53
Union Carbide Plastics Co., Division of Union Carbide Corporation 53
Union Switch & Signal, Division of Westinghouse Air Brake Co. 177
United States Gauge, Division of American Machine and Metals, Inc. 92
United States Graphite Co., The, Division of The Wickes Corporation 90
United States Steel Corporation, Subsidiaries 29, 68, 69, 70, 71
United States Steel Export Co. 29

Vapor Heating Corporation, Roth Rubber Co. Division 102
Veeder-Root, Inc. 217
Vickers, Inc., Division of Sperry Rand Corporation 199
Vickers, Inc., Division of Sperry Rand Corporation, Electric Products Division 207
Viking Pump Co. 214
Virginia Gear & Machine Corporation 60

Waldes Kohinoor, Inc. 99
Waldron, John, Corporation 229
Warrick, Charles F., Co. 222
Waterman Engineering Co. 27
Weckesser Co. 229
Westinghouse Air Brake Co., Union Switch & Signal Division 177
White, S. S., Plastics Division 228
Whitney Chain Co. 187
Wickes Corporation, The, The United States Graphite Co. Division 90

Yardley Plastics Co. 218
Young Radiator Co. 164

Engineers Available or Wanted 230

TIPS AND TECHNIQUES

VOLUME I

DRAFTING AIDS

- **Helpful Drawing Techniques**
- **Simplifying Drafting Practices**
- **Protecting Prints and Drawings**
- **Modifying Equipment for Extended Use**
- **Getting the Most from Drawing Instruments**

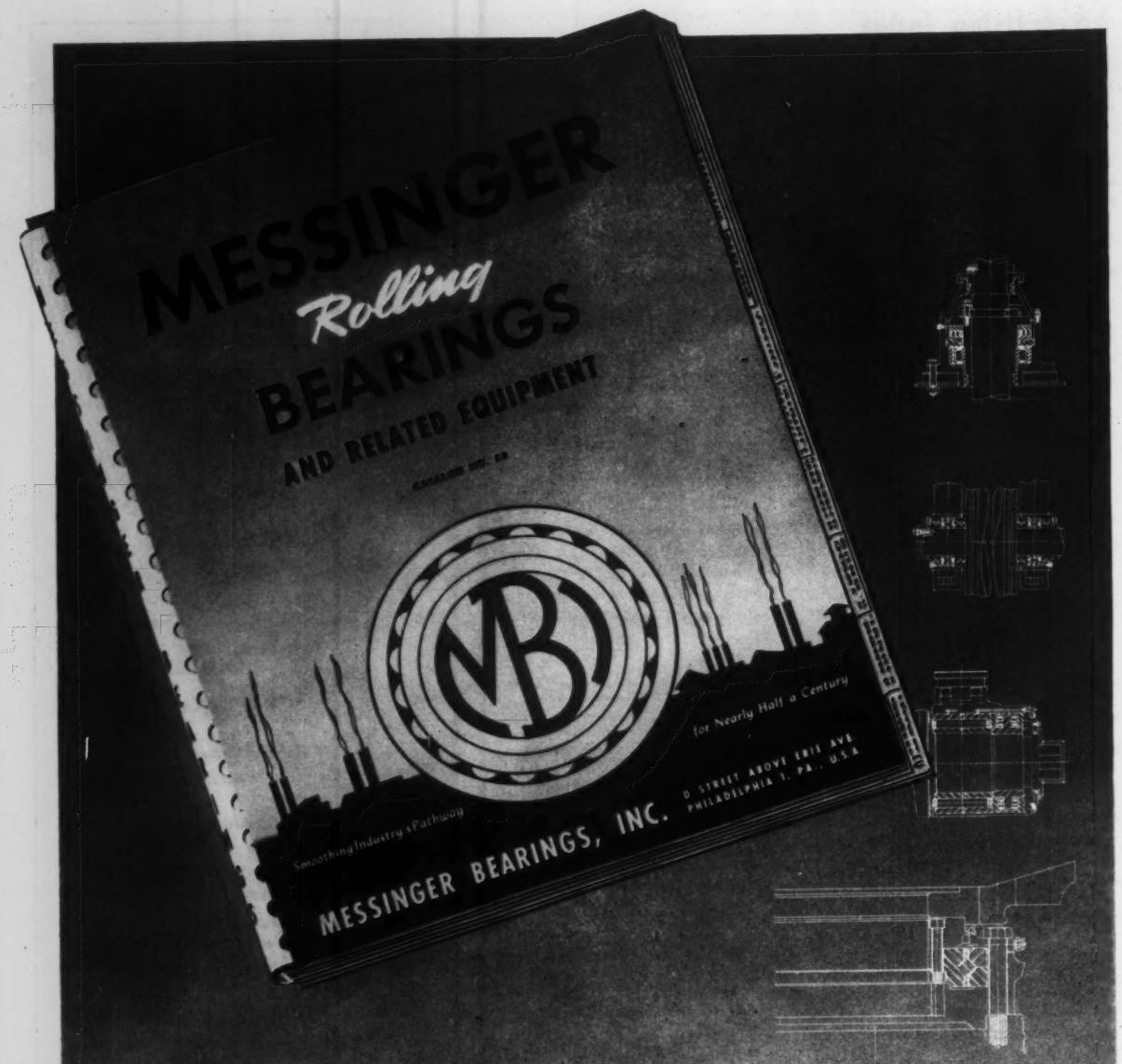
Helpful Tips and Techniques that apply to drafting practices, are now available in this one-volume reference. It contains 32 pages of practical drafting shortcuts every engineer can use.

$1.00 a copy

Order from

MACHINE DESIGN
READER SERVICE
Penton Building
Cleveland 13, Ohio

(Remittance or Company Purchase Order must be enclosed with order.)



THIS CATALOG will give you an entirely new concept of the relationship between a product and its bearings. Used at the drawing board, it will in all probability lead to important reductions in dimensions, weight and over-all costs of the machine or other equipment under development, as well as its increased efficiency and length of service. It will place at your right hand the experience of nearly 50 years of Roller Bearing advancement. Send for your copy, today.

Once it is determined that bearings are required, consultation with Messinger Engineers is the logical next step. No obligation incurred.

MESSINGER BEARINGS, Inc.

ROLLER AND BALL BEARINGS — *FEATHERWEIGHT TO HEAVYWEIGHT*

D STREET ABOVE ERIE AVE. • PHILADELPHIA 24, PA.

"Smoothing Industry's Pathway for Nearly Half a Century"

Circle 577 on Page 19

and here's how Pheoll solved it

Relaxation comes easy to a man who just saved his company $10,312! That's what happened when Pheoll looked to see if economies could be effected in the assembly of a power chain saw. A typical Pheoll-team study of the problem led to the development of a special self-tapping screw for attaching cylinder to crankcase.

Previously, the part was milled from 1⅞" bar stock, involving several operations that removed more than half the total weight. The new part is cold headed and extruded by Pheoll to the specified structural requirements from a special steel rod less than half the diameter of the original stock. There is virtually *no scrap loss* . . . with considerable savings in both material and machining time effecting a cost reduction of $4.02 per thousand units!

The Pheoll team can upgrade your product too, at reduced material and assembly costs. Let us show you how. Contact your Pheoll field man or write . . .

Pheoll Manufacturing Company, Inc.

5700 WEST ROOSEVELT ROAD CHICAGO 50, ILLINOIS

Circle 402 on Page 19

PHEOLL

P

HEADING THE FASTENER INDUSTRY FOR OVER 50 YEARS

This nut saved money because we made the hole

You're looking at one of the nuts that fits a casing bolt on a General Electric steam turbine. These nuts have to be of a special alloy steel because they are highly stressed at operating temperatures. The steel must have very high "creep strength"—keep its strength and dimensions at high temperature.

The General Electric Company was making these nuts from alloy steel bars. That was expensive because it meant drilling a large hole as the first operation.

Timken Company metallurgists said they could make seamless steel tubing of the same analysis and properties. And with the hole already there, this would eliminate the rough drilling operation—save a major machining cost.

We furnished Timken seamless steel tubing of the proper size so that after threads were cut, and the castellated heads machined, the nuts were finished up to the specified dimensions. And because Timken steel tubing is rotary pierced, it has the forged quality to give these nuts the strength they need.

This is another of the hundreds of tough steel problems that Timken Company metallurgists solve in every corner of industry. Many of these problems are apt to be much like yours. Why not let our 40 years of steelmaking experience work for you? Have your next steel problem stamped "Solved" in jig time. Call in Timken Company metallurgists. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO". *Makers of Tapered Roller Bearings, Fine Alloy Steels and Removable Rock Bits.*

WHEN YOU BUY TIMKEN STEEL YOU GET:

1. Quality that's uniform from heat to heat, bar to bar, order to order
2. Service from the experts in specialty steels
3. Over 40 years experience in solving tough steel problems

TIMKEN ALLOY STEEL AND SEAMLESS STEEL TUBING ARE AVAILABLE FROM WAREHOUSE STOCKS IN 44 CITIES IN THE UNITED STATES

Circle 403 on Page 19